Report

OF THE DIRECTOR OF

SCIENCE SERVICE

FOR THE YEAR ENDED MARCH 31,

1949/1950

DEPARTMENT OF AGRICULTURE, OTTAWA, CANADA.

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For the Year Ended March 31, 1950

SCIENCE SERVICE

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SCIENCE SERVICE

The Science Service is responsible for investigations in a wide variety of agricultural and scientific subjects such as destructive and useful insects, diseases of plants and animals, taxonomic botany, chemistry, bacteriology and laboratory phases of dairy research. The main function of the Service is agricultural research and experimentation, though it also assumes responsibility for plant inspection, particularly with respect to preventing the introduction of insects and plant diseases from other countries, and potato certification. Moreover, partly because laboratories are widely scattered and partly because the Service is the only local source of reliable information on many subjects, a certain amount of advisory work is inescapable.

The Service is made up of the following divisions: Animal Pathology, Bacteriology and Dairy Research, Botany and Plant Pathology, Chemistry, Entomology, and Plant Protection. Detailed reports on work in progress in divisions follow this introductory statement.

To some extent for many years, and particularly in recent times, the work in various divisions has converged on important agricultural problems requiring for solution the attention of diverse specialists. This tendency is becoming increasingly apparent not only among divisions of Science Service, but also in connection with work in progress in Experimental Farms Service. Association between scientists of the two services is intimate at many locations; notably Charlottetown, Fredericton, Ottawa, Winnipeg, Saskatoon and Lethbridge.

An extensive building program was planned four years ago and is now well under way. The plan has been developed with a view to the establishment of a few well equipped and staffed regional research laboratories, and numerous field laboratories required for problems of more or less local occurrence that must be studied where found. Most of the field laboratories have been active for many years and an attempt will be made to operate any additional ones that may be necessary on a seasonal basis only.

Procurement and occupation of the Records Building in 1948 was perhaps the most important event in the history of the Service. Here, the Administration Division is well accommodated and the Division of Entomology has been provided with excellent office and laboratory accommodation. Well equipped laboratories are provided for the bacteriological work of the Division of Bacteriology and Dairy Research and for the vitamin unit of the Division of Chemistry. Headquarters of the Division of Plant Protection is also housed in what is now the Science Service Building. A headerhouse and two greenhouses are now under construction.

A large and well equipped regional laboratory has been established at Lethbridge on property adjacent to the Experimental Station.

A large modern laboratory is nearing completion at London, Ont. This laboratory will be devoted primarily to research on insecticides, fungicides, herbicides and soil fumigants.

In the fiscal year, 1950-51, work will begin on a large regional laboratory on the campus of the University of Saskatchewan. This will include laboratories of forest entomology and pathology and agricultural entomology and plant pathology. Chemical and bacteriological laboratories are included and accommodation is being provided for the Forage Crops Laboratory of Experimental Farms Service and the Saskatoon section of the Economics Division of Marketing Service.

Plans are also on foot, and construction will begin in 1950-51, for new laboratories for forestry research at Fredericton, N. B., and agricultural research at Kentville, N.S., and Ste. Anne de la Pocatiere, Quebec.

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HIGHLIGHTS OF THE YEAR'S WORK

Animal Pathology

An investigation has shown that the "Ring Test" has value as a screening method in Brucellosis diagnosis.

Attention has been focused on the selection of antibiotics for their action on specific types of infection in mastitis.

Successful research accomplishments in coccidiosis of chickens has so mastered this infection that it need no longer be an economic liability.

Considerable advances have been made in the knowledge of blackhead of turkeys which will yield economic benefits.

Evidence is accumulating that rhinitis of swine may be caused by a combination of two separate agents attacking the animal while it is young.

Improved methods of diagnosis have been developed for Newcastle disease. A large stock of vaccine has been prepared for use if needed, which is incapable of setting up disease but produces an immunity of short duration. Another strain of virus has been studied. It does not produce disease in older birds and gives longer protection.

Two new strains of tubercle bacilli have been isolated, which show unusual promise for the production of a more potent tuberculin free from the non-specific qualities of most tuberculins.

The possible relationship of certain factors in the diet to certain properties of blood serum has been shown. New methods have also been developed for measuring the antibody content of serum. Many requests for information about this are being received from other parts of the world.

The toxicity of new insecticides is being studied. The properties of DDT and parathion have been thoroughly investigated and a number of other substances are now under study.

Approximately 145,000 blood tests for Brucellosis have been made.

Some 4,542,064 doses of biological diagnostic products have been distributed for use during the year.

Bacteriology and Dairy Research

Detergent-sanitizer compounds showed considerable promise in milking machine sanitation though none surpassed the older lye solution method.

Associative action of aerobic and anaerobic spore-forming bacteria is believed to be responsible for flavour spoilage in process cheese.

The degree of fat acidity is closely correlated with the development of rancid and unclean flavours in Cheddar cheese.

Roller-dried skim-milk has been found to contain anaerobic bacteria similar to those causing spoilage in process cheese.

A continued improvement in the bacteriological quality of frozen egg reflected the assistance given to the industry by the Division.

Certain species of bacteria contaminating vegetables were much more resistant to freezing than others; moulds were more resistant than bacteria.

A preliminary survey of the quality of pickles on the retail market showed the need for considerable improvement.

Study of the specific requirements of soil bacteria requiring amino acids, a group preferentially stimulated by the growth of plants, showed methionine to be by far the most essential compound.

In the correction of manganese deficiency symptoms in plants by application of soil fumigants, compounds containing nitrogen were found to exert the most beneficial effects. Similarly good results were obtained from application of calcium nitrate and ammonium sulphate.

Quantitative-qualitative studies on bacteria associated with seeds of six crop plants indicated that seeds have a characteristic microbial flora differing from types most common to soil. There is evidence that seeds of different crops vary with respect to their predominant epiphytic types.

Sulphadiazine at the rate of 0·5 grams per gallon of a 50 per cent sugar syrup was as effective as sodium sulphathiazole in preventing infection of honeybee larvae with American foulbrood.

Evidence has been obtained that the mechanism of inhibition of American foulbrood by sulpha drugs involves interference with the metabolism of the purines guanine and xanthine, which *Bacillus larvae* requires for growth.

A hitherto undescribed bacillus was isolated from powdery larval scale of honeybees and named *Bacillus pulvifaciens.*

The resistance of bacterial cells to destruction by quaternary ammonium compounds is unrelated to their resistance to phenol and shows an entirely different shape of survivor curve.

In a survey of actinomycetes occurring in uncultivated soils from various points in Northern Canada, a high proportion of the types were found to exhibit antibiotic effect against a series of test organisms including plant pathogenic fungi.

Various antibiotics, especially polymyxin and aureomycin, exert bacteriostasis of *Xanthomonas phaseoli* and *Pseudomonas phaseolicola* (cause of common and halo blight respectively of beans) at very low concentrations *in vitro.*

Bacteriophages for *Xanthomonas phaseoli* and *Pseudomonas phaseolicola* have been isolated and applied successfully in the diagnosis of infection of beans with these internally-borne pathogens.

Many bacteria isolated from soil and manure, as well as many soil actinomycetes, were found to be capable of synthesizing vitamin B_{12} in detectable amount.

Botany and Plant Pathology

Some 17,800 labelled specimens of Canadian plants were distributed on an exchange basis to institutions in Canada and foreign countries. Authentic examples of Canadian plants appear to be greatly in demand by botanists of other countries.

The botanical herbarium expanded rapidly in 1949; an addition of 26,595 sheets brought the total number of specimens in the herbarium to 128,000.

In a new approach to the weed problem, the Division organized a co-operative survey of the persistent perennial weeds in the Prairie Provinces, a scheme financed and directed by the Department but largely conducted by provincial workers. Results of one year's study indicate that these weeds are more firmly entrenched than previously realized and that their control is a problem of major importance.

Of the 1,083 cultures of Hymenomycetes isolated from rots and stains in decay studies on various tree species across Canada in 1949, 931 or 85 per cent were identified and assigned to 45 species of which 27 were species of the Polyporaceae.

In the first study of decay in maple, it was found that 80 per cent of the living hard maple trees contained decay caused by 26 fungi. Entry through seams accounted for 40 per cent of the cubic volume of decay.

Pole blight, a disease of unknown cause, was found to be prevalent over most of the commercial range of western white pine in the interior of British Columbia. It is causing the death of an appreciable number of trees of pole size.

Leaf rust of wheat was the only cereal rust that caused appreciable damage in Canada in 1949. Severely rusted crops ripened prematurely and gave disappointing yields. In the Prairie Provinces, new virulent races occurred almost exclusively. Present studies gave little clue to their origin.

A seed drill survey of coarse grains in Manitoba indicated that only half the farmers treat their seed for smut.

Examination of whole embryos of barley seed holds promise as an accurate routine method of determining the percentage of loose smut that will develop in the crop when the grain is sown.

Certain isolates of *Helminthosporium sativum*, the cause of common root-rot of wheat, when appropriately paired on a suitable medium, produce mature perithecia of the perfect stage, *Cochliobolus sativus*.

Arasan has proved effective in the control of common root-rot of wheat in greenhouse tests. By its use in small plots reliable data should be procurable on the losses caused by this important disease.

The finding of bacterial wilt in alfalfa in eastern Ontario suggests that the disease will eventually be found throughout Canada.

Selection for disease resistance in hybrid alfalfa is progressing favourably. Lines possessing a high degree of resistance to wilt have been obtained from crosses between wilt-resistant and crown-rot-resistant plants.

A destructive root-rot of sweet clover in southwestern Ontario was found to be caused by *Phytophthora Cactorum*.

Promising potato seedlings that possess resistance to one or more of the diseases late blight, bacterial ring rot, and common scab have been found in trials of hybrid progeny produced at Fredericton.

The potato variety Teton again proved highly resistant to bacterial ring rot.

The potato rot nematode survived for three years in soil under fallow or cropped continuously to potatoes, although apparently in diminished numbers. Absence of cultivation or fumigation with chloropicrin resulted in increased infection when the land was again planted with potatoes.

Soil fumigants were effective against brown root-rot of tobacco through the destruction of nematodes in the soil.

Preliminary studies revealed that resistance of apple seedlings to apple scab could be readily determined by atomizing the seedlings with spore suspensions obtained from artificial cultures of the scab fungus.

Little leaf and rosette, a disorder of apple trees, was corrected with a dormant spray of zinc sulphate.

Some evidence was obtained that cherry yellows in the Niagara Peninsula is caused by two viruses in the same tree, one that causes necrotic ring spot in cherry and the other, prune dwarf in Italian prune.

Further studies of the fungi causing leaf diseases of strawberry resulted in the finding of *Zythia Fragariae* associated with the leaf blight fungus, *Dendrophoma obscurans*. Its importance as a pathogen is unknown.

An antibiotic substance was successfully applied for the first time as a seed treatment in the control of a disease caused by a seed-borne fungus.

Chemistry

When carbohydrate concentrates, like barley, were fed to cattle at maximum levels of feeding there was a definite reduction in the amount digested.

The proportion of the component feeds in the Canadian Advanced Registry swine testing station ration was varied without affecting their individual feeding values.

Swine did not digest very readily high fibrous feeds, such as alfalfa meal, but the fibre in these feeds had no effect on the digestibility of other components of the ration.

Mustard seed oilmeal had a lower content in digestible feed nutrients than other oilmeals such as linseed and soybean.

Herbage cut at the proper stage of maturity and cured even under mildly adverse conditions had a higher value than when it was cut after maturity.

Potassium iodate incorporated into salt blocks was stable under pasture conditions where potassium iodide was not.

Roadside weed killers containing sodium chlorate were used without danger to cattle when the manufacturers' directions were followed and the necessary precautions taken.

Controlled feeding of test animals improved respiratory metabolism studies on thyroid-active compounds.

A condition resembling uroporphyrinuria or pink tooth in cattle has been described.

A survey of Ontario orchards by leaf tissue analysis indicated generally satisfactory nutritional levels.

The buying quality of McIntosh apples was not related to certain fractions of nitrogen and phosphorus in the fruit.

The coumarin content of selected sweet clover plants varied from a trace to 0·44 per cent.

The blackening of potatoes upon boiling was apparently related to the copper content (after boiling) of the blackened area.

Spray residues of lead, arsenic, parathion and DDT on fruits were in general well within tolerances.

Improvements were made in the fusion analysis of soil samples to overcome erroneous results in magnesium determinations due to large amounts of manganese.

Waste sulphite liquor solids when applied to soil resulted in increases in moisture equivalent and in the size of water-stable aggregates.

Considerable increases in soil reaction, exchangeable calcium and base saturation and decreases in exchangeable manganese resulted from applications of ground limestone at Charlottetown.

Montmorillonite and illite were tentatively identified as the predominant minerals in a brown podozolic soil profile.

Paper chromatographic techniques have been adapted to the microdetermination of a variety of compounds in studies on soils, plants and animals.

Apple juice and apple sauce from a parathion sprayed crop were apparently free from parathion.

Incidences of leaf scorch of apple trees have been correlated with the potassium: magnesium ratio in the leaves.

A dying back of young twigs on apricot trees was associated with extremely high boron content.

The mercury complexes of cupferron and of phenylthiohydantoic acid were very effective seed protectant fungicides.

Two new insecticides, aldrin and dieldrin, were shown to be respectively four and eight times as effective as chlordane for the control of grasshoppers. However, they are extremely dangerous to use because of their high toxicity to warm-blooded animals.

The wheat stem sawfly continued to cause increased loss of winter wheat in Alberta, and investigations were initiated to determine whether a distinct strain of rapidly maturing sawfly is developing in this crop.

Parathion spray gave better results than the other insecticides tested against the European corn borer in southwestern Ontario, provided the most promising control of the pea moth yet obtained in Eastern Canada, was effective against the early nymphal stages of the pine needle scale in the agricultural areas of the Prairie Provinces, and gave highly satisfactory control of a number of insect pests of Canadian orchards.

As a result of further successful tests, chlordane is now recommended for the control of the first generation of the carrot rust fly in Ontario.

Air pressure was found to be an important factor affecting the abundance and distribution of the imported cabbage worm. Increased oviposition occurred when the barometric pressure was low, and alternating periods of high and low pressure tended to disperse the population and to promote egg-laying over wide areas.

Further evidence was obtained in support of the assumption that air currents transport potato aphids across the Northumberland Strait, from New Brunswick to Prince Edward Island.

In investigations conducted at St. Jean, Que., the amino acid content of peas was found to be correlated with resistance to attack by the pea aphid, the acids being less abundant in resistant than in susceptible varieties.

Testing of an automatic sprayer for the application of concentrated mixtures, originally developed and now widely used in British Columbia, was extended to Eastern Canada to determine the possibilities of the machine under different conditions. It was shown to have wide possibilities, particularly if certain modifications are made for eastern conditions.

Further evidence was obtained in 1949 of the marked influence of weather conditions on the infestations of the oriental fruit moth. As in previous years, an early spring followed by a hot dry summer was very unfavourable for the insect. Although the season in general was very warm, low evening temperatures near the times of maximum emergence of the spring and third broods undoubtedly decreased the activity and oviposition of the moths.

In the Maritime Provinces studies show that the European spruce sawfly is now under control, largely because of the introduced parasites and the virus disease. Several of the introduced species of parasites have become well established and have proved of value at low levels of sawfly population. The virus has been propagated in the laboratory for release in newly infested areas.

Two new pests of shade trees were discovered in the Maritimes: the elm leaf beetle and the European winter moth. Methods of chemical control have been partially worked out.

A survey of forest insect conditions in Newfoundland showed that the balsam woolly aphid has become established on the island. This insect has also reached northern New Brunswick. The introduced predator, *Leucopis obscura* Hal., has become widely established and is delaying the spread of this pest.

A study of the spruce-balsam stand on the Green River watershed in New Brunswick showed that the damage during the 1914-18 outbreak of the spruce budworm was related to age and vigour of the trees; stands under 45 years old survived, whereas those over 60 years suffered severe mortality.

The use of frass-drop measurements has been extended to sampling of populations of the spruce budworm on balsam fir.

The spruce budworm increased greatly in numbers in parts of northern New Brunswick and evidence of mass flights into New Brunswick was obtained by light traps.

Continued studies of the influence of weather on fluctuations in the populations of the spruce budworm and the forest tent caterpillar indicated that the two species tend to increase in numbers at different periods in the climatic cycle. The heavy feeding period in a tent caterpillar outbreak usually precedes the beginning of a spruce budworm outbreak in the same area by 2 to 4 years.

Spruce budworm populations are heavier on flowering than on non-flowering balsam fir; development is more rapid on flowering trees, and moths tend to lay greater numbers of eggs on flowering trees. These results are consistent with the observation that infestations usually develop in over-mature forests rather than in young, vigorously growing forests.

Studies of "dieback" of birch in a typical area in northern New Brunswick showed 70 per cent of the merchantable volume dead, 15 per cent severely injured, and 15 per cent recovering. The bronze birch borer is only a secondary cause of the injury. Young stands are relatively resistant. Methods of management to maintain vigour are indicated.

DDT emulsion sprays applied to the bark of elm trees in the early spring remained lethal to the native elm bark beetle, carrier of the Dutch elm disease, throughout the growing season. Plots in which bark-beetle brood trees and diseased trees were sprayed early in 1948 showed no increase in the number of diseased trees and no new brood trees late in 1949.

High water levels in tamarack swamps will not damage overwintered cocoons of the larch sawfly in the spring unless flooding is prolonged or occurs in mid-June, when most of the sawflies in cocoons are developing.

DDT applied as a concentrated spray to tree trunks in farm shelter-belts just before the emergence of the fall cankerworm moths materially reduced the amount of oviposition by this species.

The investigation of biting fly distribution and biology, as well as a general northern insect survey, was continued at 11 widely distributed locations across arctic and sub-arctic Canada. Much valuable information on biting fly behaviour was obtained, and approximately 100,000 insect specimens were taken for the Canadian National Collection. Collaborating officers from the medical divisions of the United States Army and Navy conducted preliminary investigations of the use of radio-active isotopes in tracing the dispersal of biting flies.

Investigation showed that the carrot rust fly is free from attack by parasites in Canada. Two species of parasites obtained from England were released in Ontario and British Columbia during 1949.

Fourteen species of parasites obtained from Europe and British Columbia were released in Eastern Canada to aid in control of the spruce budworm.

Characteristics that may be used to identify closely related species were found in the chromosomes of parasitic Diptera.

A synthetic diet, composed entirely from chemicals, was developed for propagation of a dipterous parasite of the spruce budworm. This is an improvement on the artificial medium of liver and fish developed in 1948, and is the first known record of the propagation of a parasitic insect on a wholly synthetic diet.

Studies on the natural control of biting flies were started in 1949 at Churchill Man., and provided valuable information on the importance of predators in regulating abundance.

At Goose Bay, Labrador, it was found that mosquito abundance and activity increased in a steep gradient from open to transition to forested areas, and that the removal of forest growth from the vicinity of human habitations in forested regions had practical value in providing relief from these pests.

The effectiveness of aerial spraying of DDT in oil solution in securing protection against mosquitoes in limited areas was demonstrated at Whitehorse and Watson Lake, Y.T., Fort Nelson and Fort St. John, B.C., and Goose Bay, Labrador.

Field experiments with various formulations of methoxychlor, toxaphene, chlordane, gamma benzene hexachloride, dieldrin, aldrin, 1,2,4-trichlorobenzene, a pyrethrum-piperonyl butoxide mixture, and parathion showed none of these to be so satisfactory as DDT for controlling black fly larvae in streams. For this purpose DDT was harmless to fish when applied in solution in fuel oil at 0·1 part of DDT per million parts of water for 15 minutes, but a similar dosage of DDT applied as a concentrated solution in methylated naphthalenes killed numerous fish that swallowed globules of the larvicide.

Plant Protection

Importations of 58,399,108 plant units, comprising 25,548,906 plants and 32,850,202 bulbs were inspected on arrival for insects and diseases.

Exports of 908,481 plants, 4,442,028 bulbs, 6002 pounds of tree and miscellaneous seeds were inspected and certified before shipment to 32 countries. Exports of plant products, certified as a requirement of the importing countries, 31 in number, consisted of 14,278,090 pounds of table potatoes, 196,217,040 pounds of wheat, 4,079,581 pounds of malt, 38,760 pounds of vegetable seed, 45,900 pounds of minute oats, 67,000 pounds of frozen blueberries, 84,000 pounds of alfalfa seed, 10,000 pounds of flour, 10,000 pounds bulk corn seed, 2000 pounds of miscellaneous seed and 53,476 Christmas trees.

Imports of plant products, involving 91,838,310 pounds were examined for infested or infected material.

The examination of passengers' baggage for plant material was carried out in co-operation with Customs officers, principally at ocean ports. Special arrangements were made to have inspectors of the Division located at important Canada-United States border points during the busy tourist season.

Interceptions were made on imported plants and plant products on 1,193 occasions.

The inspection of cargo vessels at ocean ports, previous to loading grain and cereal products for export, was extended during the year and 1,381 vessels were examined and 255 of these required fumigation or cleaning.

Large quantities of insect infested broom corn and peanuts were successfully fumigated in box cars, under the supervision of Division of Plant Protection officers before delivery to importers, and a variety of infested and infected commodities were treated at the Divisional Fumigation and Research Laboratory in Montreal, where investigational and experimental work is being continuously conducted on various projects.

The main field projects consisted of the Dutch Elm Disease survey in Quebec and Ontario, which also included the supervision of the removal of infected trees in both provinces; Japanese beetle trapping in three provinces and the Oriental fruit moth survey in British Columbia. Other field activities carried on with the co-operation of Federal and Provincial agencies were apple maggot control and surveys in Ontario, Quebec, New Brunswick, Nova Scotia, and the grader inspection of fruit for scale insects in British Columbia.

The acreage of potatoes entered for certification throughout Canada was over 72,000, representing an increase of nearly 3,000 acres over 1948. Slightly over 89 per cent of this acreage passed field inspections. Approximately $9\frac{1}{4}$ million bushels of Foundation and Foundation A were produced out of a total of $18\frac{3}{4}$ million bushels from fields passing inspection in the three classes. Shipments from the 1949 crop to March 31, 1950, totalled 5,609,549 bushels, of which 5,409,549 were exported to 17 countries and 200,000 bushels were sold to domestic markets. Exports to the United States alone were 4,535,795 bushels.

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DIVISION OF ANIMAL PATHOLOGY

The Division of Animal Pathology comprises a central institute (Animal Diseases Research Institute, Hull, Que.) and five branch laboratories located as follows: Vancouver, B.C., Lethbridge, Alta., Macdonald College, Que., Sackville, N.B. and on the Experimental Farm, Ottawa.

The work of the Division may be classified under three main headings: research, services, and the manufacture of biological products.

Research

Infectious Abortion (Bang's Disease).—Research has continued on this disease and ways and means of increasing the resistance of adult animals have been explored. Although there is some indication that biological products may be of assistance there is still very much left to be desired in this special phase of the disease.

Newer methods of diagnosis, particularly the "Ring Test", have been studied and modifications developed which would appear to make possible the use of this particular procedure.

Infectious Mastitis.—Because of lack of staff this subject has not received the attention it deserves. Nevertheless experiments have been carried on particularly relating to the effect of antibiotics on organisms which colonize in the udder, other than streptococci. Attempts are being made to determine what antibiotic substance will be most suitable for infection brought about by various organisms.

Coccidiosis of Chickens.—The successful research accomplishments in this field have in large measure robbed the infection of its economic liability. Attention has been given to determining under actual field conditions the best way in which the various substances which have proved of value may be put to use, keeping in mind of course that the expense to the poultry industry must ever be given consideration.

Pullorum Disease.—Because of the successful working out of details in regard to this infection in the immediate past, this disease has ceased to become as important to Canadian poultry as formerly. Nevertheless, there are problems left which require solution. One of these is ways and means of determining the presence of the infection in incubators, having regard to the shipment of this potentially infected material for considerable distances. Lately, a means has been worked out which would appear to make possible the survey of incubators used in commercial hatcheries across the country and thus tend to correct the disease at its very source rather than allow it to spread out into the chick population.

Enterohepatitis of Turkeys.—This important disease of turkeys has placed a limit upon the production of these birds and even when they have been produced it was at considerable expense and under an artificial environment.

Much basic research has been conducted on the disease and many factors have been brought to light which it is believed in the early future may yield practical economical results. Also, a number of newer drugs have been studied and one or two have shown considerable promise in controlling the infection.

Rhinitis of Swine.—This interesting condition which appears to be an exceedingly complicated infectious process has received much attention. Obviously, the study of a disease of this kind is costly in time and money since large groups of pigs must be used. To date the actual cause remains undiscovered, although the condition has been transferred from swine to swine under experimental conditions. Evidence is accumulating which tends to suggest that the disease is caused by a combination of two separate agents attacking the animal while it is still young. The condition seen in the adult animal is the aftermath of an infectious process which took place several months earlier.

Newcastle Disease.—A great deal of attention has been given to Newcastle disease, a spreading and fatal disease of poultry, particularly of young birds. Improved methods of diagnosis have been devised and established. The method of spread from bird to bird has been under investigation. One interesting point is that the male bird would appear capable of transferring the infection by mating with hens.

Studies on a vaccine have been completed and a large stock of this product has been prepared against the day that it may have to be used. This vaccine is incapable of setting up the disease in susceptible birds and on the other hand the immunity resulting is of comparatively short duration, usually not exceeding three months. A new strain of virus has been discovered which is incapable of causing disease in older birds although it will bring about immunity in these. This immunity appears to last for a considerable time, perhaps for life. There are certain features, of course, which are liabilities. It stimulates the same blood reaction as is brought about by a normal infection and therefore complicates a diagnosis.

Tuberculin Studies.—Studies have continued on tuberculin and although this subject has been under investigation for many years there is still much to learn relating to a more specific product. Almost 50 strains have been isolated and their antigenic structure in large measure determined, also their capacity of producing tuberculin. Of these, two have shown unusual promise and may lead to the production of a tuberculin which is not only highly potent but is restricted in its activity in regard to animals that may be sensitized with other tuberculous-like organisms.

Serological Studies.—Several of the basic problems of immunology are intimately associated with serological studies and the capacity to resist invading organisms is perhaps related to certain factors which are not understood at present. An exploration of these fundamental factors is under way and several interesting findings have resulted. Among them is the possible relationship of certain factors in the diet to certain properties of the blood serum. New methods have also been developed for measuring the antibody content of the serum.

Studies on Toxicity for Warm-blooded Animals of Insecticides.—Certain insecticides are coming into use which possess potential toxicity for warm-blooded animals. In an effort to determine the doses which will produce symptoms or death in various species of animals by various routes, an extensive experimental study has been undertaken. The properties of DDT and parathion in this respect have been thoroughly investigated, and a number of other substances are now under study.

Services

Laboratory services are given to veterinarians, physicians, livestock owners and others. These services are made up of diverse types of work, including post mortem examinations, serological, pathological and bacteriological tests, also studies in the field of parasitology. Work for other Departments includes the examination of chemical substances for which certain claims are made and which are presented for registration; the manufacture of medico-legal serums for the Royal Canadian Mounted Police; and the development of certain diagnostic serums for other laboratories. Considerable time is also taken in reviewing for other Departments the literature in connection with certain claims for chemical substances, and checking radio advertising to prevent exploitation. of the public.

Serological Tests for Bang's Disease

Animal Diseases Research Institute, Hull, Que.	101,999
Veterinary Research Laboratory, Lethbridge, Alta.	10,166
Pacific Area Branch Laboratory, Vancouver, B. C.	5,530
Maritime Area Branch Laboratory, Sackville, N.B.	22,628
Montreal Area Branch Laboratory, Macdonald College, Que.	5,008

Serological Tests for Pullorum Disease

Maritime Area Branch Laboratory, Sackville, N.B.	891
Poultry Pathology Laboratory, Ottawa, Ont.	1,841

Miscellaneous Specimens and Post Mortem Examinations

Animal Diseases Research Institute, Hull, Que.	666
Veterinary Research Laboratory, Lethbridge, Alta.	341
Pacific Area Branch Laboratory, Vancouver, B.C.	866
Maritime Area Branch Laboratory, Sackville, N.B.	264
Montreal Area Branch Laboratory, Macdonald College, Que.	983
Poultry Pathology Laboratory, Ottawa, Ont.	1,215

Manufacture of Biological Products

Biological products are manufactured on a large scale and these are issued to Veterinary Inspectors, to other Departments and to persons engaged in the diagnosis or control of animal diseases. The following is a summary of the products distributed this year:—

Tuberculin	4,222,116 doses
Mallein	5,834 "
Johnin	1,110 "
Brucella abortus antigen—Tube Test	188,339 test doses
—Rapid Test	11,665 " "
Pullorum disease antigen	113,000 " "

DIVISION OF BACTERIOLOGY AND DAIRY RESEARCH

Dairy Research

Milk.—In co-operation with the Animal Husbandry Division, Experimental Farms Service, further tests have been conducted on the cleaning and sanitizing of milking machines. Four detergent-sanitizer products were tested, three of which gave satisfactorily low counts on the milk, one product giving surprisingly low counts when used in cold solution. Although the detergent-sanitizers were very effective as cleaning agents, none of these products gave counts on the milk as low as those obtained by the regular lye solution method developed by this Division. The effectiveness of the latter method was further demonstrated over a 6-week period during which the milk was allowed to dry on the teat-cup assembly which was then filled with a weak lye solution. The average count on 37 samples of milk obtained with the units so treated was 8,100 per ml. while very little film or deposit remained on the rubber parts.

The program for the control of chronic contagious mastitis, in co-operation with the Animal Husbandry Division, has been continued. After three years of freedom from infection with *Streptococcus agalactiae*, the causative organism, one cow previously clear was found in May, 1949, to be infected in one quarter. Penicillin treatment was instituted immediately, and no further evidence of infection has been found in subsequent tests. Bacteriological control of the Central Experimental Farm dairy operations was maintained during the year.

Cheese.—Studies of defects of process cheese brought to our attention by the industry during the year were continued. Though in the earlier work on the cause of putrefactive bacterial spoilage *Clostridium sporogenes* was identified as the causal agent, the study of further spoiled samples revealed the presence of other anaerobic bacteria to which the defect may be attributed. Further cases of flavour defects have been brought to the attention of the Division with which both an aerobic and an anaerobic spore-forming organism are concerned. While the relationship of the two types in causing spoilage is not clear, a synergistic action is suggested whereby the oxidation-reduction potential is altered by the aerobe to a point favourable for development of the anaerobe.

Further studies have shown that the degree of fat acidity is closely correlated to the development of rancid and unclean flavours in Cheddar cheese. Considerable attention was given to improving procedures for fat acidity determination and for estimating the numbers of lipolytic bacteria. Demeter's Nile blue sulphate medium was found to be more selective than Starr's spirit blue medium for counting the more active fat decomposing forms.

The desirability of keeping commercial Cheddar cheese free from mould growth previous to paraffining for storage has long been advocated. As a non-toxic fungicide must be used on food products, the use of a new chemical compound sold under the trade name of 'Nipasol M' was investigated. Using various species of fungi isolated from Cheddar cheese surfaces, trials with this product gave good inhibition in a 2 per cent concentration.

The carryover of antibiotics injected into quarters of cows infected with mastitis into the milk is becoming an increasingly important consideration among cheese manufacturers since these antibiotics inhibit the lactic streptococci in starter cultures. Penicillin is particularly active in this connection, consequently an attempt was made to develop a penicillin-resistant starter culture. This was achieved and the resulting culture was capable of coagulating milk containing 3·0 units penicillin per ml. whereas the original, unadapted culture could not do this in milk containing 0·2 units per ml. Resistance was maintained successfully for 55 transfers in absence of penicillin. However, after 109 transfers this characteristic was lost. Consequently it is considered that this method does not hold much promise unless a permanently resistant culture is obtained.

Dry Milk.—During 1949, 12,583 samples of roller and spray-dried skim-milk were analysed for sediment, acidity, colour, flavour and bacteria counts for grading purposes. Of the total samples, 26·8 per cent were spray dried, and were also tested for solubility index. The samples of spray-dried powder represented 46·1 per cent of the total powder graded, an increase of about 15 per cent over the previous year. There was continued improvement in quality with 90·5 per cent in first grade, an increase of 5·3 per cent. The main defect in roller-dried powder continued to be high sediment, but some improvement was shown in controlling other defects. For spray-dried powder, high fat and moisture tests were the principal causes of degrading the powder below first grade. There was a relatively marked decrease in the percentage of spray-dried powder degraded because of high bacteria counts.

Studies of the microbiology of roller-dried skim-milk have shown relatively low plate counts at 37°C., negligible mould and yeast contamination, and negative coliform tests, indicating satisfactory processing and handling in the plants. All samples contained thermophillic organisms able to grow at 55°C., and most samples showed the presence of organisms able to grow under anaerobic conditions. However, these anaerobic types may be of considerable importance in causing defects in food products in which dry milk is used. Direct microscopic counts of the reconstituted milks ranged from 1 to 60 million per ml. and indicate that improvement could be made in handling the fluid milk supply. Most of the viable organisms surviving the heat treatment of roller-dried powders are gram positive, spore-forming rods and coccus types, many of which digest milk and liquefy gelatine. Many of the reconstituted milks show proteolysis with objectionable flavours and odours when held at 70°F. for 48 hours.

Ice Cream.—Tests were made of a modified Babcock method for determining fat in ice cream suggested by workers at the University of Illinois, in which the acetic-sulphuric acid reagent is replaced by a mixture of equal parts of perchloric acid and acetic acid. The new method was found to be speedier and gave clearer and more accurate readings for fruit and nut ice creams, provided solid particles were strained out previous to testing. However, it was found that the test cannot be used on samples of ice cream or mix which have been preserved with formaldehyde, while the reagents are more costly than with the acetic-sulphuric acid test.

In a study of methods for estimating coliform organisms in ice cream, set up in co-operation with the Sub-Committee on Standard Methods for the Examination of Dairy Products (American Public Health Association) and the Sanitary

Control Committee of the International Association of Ice Cream Manufacturers, samples of various kinds of ice cream have been examined. While results to date do not indicate any significant differences in coliform counts when dilutions are prepared from frozen ice cream or from a sample allowed to melt at 40°F. for 3 to 4 hours, in the majority of cases counts on desoxycholate agar were slightly higher with the frozen sample. There was good agreement between counts made with the solid medium (desoxycholate agar) and brilliant green bile lactose broth. Few samples showed a negative test for coliform bacteria. The counts ranged from 0 to 600 per gram, with 59 per cent of the samples having counts of 10 per gram or less. High coliform counts appeared to be associated with fruits or flavouring materials.

Food Microbiology

Egg Products.—This Division has continued to share the responsibility for the maintenance of adequate sanitation in Canadian egg breaking and drying plants. Bacteriological analysis, and especially direct microscopic examination, of all Grade A carlots has directed attention to plants having difficulty with high bacteria counts. Of the 128 samples analysed during 1949, only one failed to meet the bacteriological specifications.

Further assistance was given the Poultry Products Grading and Inspection Services of the Marketing Service in improving the bacteriological quality of frozen egg products. The Burri slant method of estimating the bacterial content was again used by their inspectors to screen out high count samples. Of 634 samples tested by the Burri slant method, only 12·8 per cent showed counts so high as to require resorting to the more expensive plate count method. Of 485 samples examined by plating, only 2·9 per cent showed counts in excess of 2·5 million per gram, while 53·2 per cent were below 250,000 per gram. These results indicate a sustained improvement in the bacteriological quality of these products.

Studies were conducted in co-operation with the Poultry Products Grading and Inspection Services and the Division of Chemistry on the influence of the method of sampling upon the bacterial and solids content of frozen whole egg. Despite the uneven manner in which the bacteria are distributed in frozen egg, in every instance the count from the sample obtained by the trier method was higher (usually double or more) than that of the drilled sample. To find the explanation of this, further studies are planned.

Edible Gelatine.—In co-operation with the Health of Animals Division, Marketing Service, the bacteriological control of edible gelatine was continued. Of 1,189 samples analysed during 1949, 93·3 per cent met the bacteriological standards set forth in the Food and Drugs Act, as compared with 95·8 per cent for 1948.

Differences occasionally encountered between the results of duplicate analyses of gelatine prompted a search for the reason. It was demonstrated that the bacteria in gelatine are very unevenly distributed and in spite of all efforts, wide variations may still occur. However, improvement in methods of dissolving the gelatine for analysis have been fairly effective in reducing variation between replicate plates poured from the same dilution, as well as those between replicate analyses.

Frozen Pack Vegetables and Fruits.—The bacteriological survey of commercial packs of frozen vegetables and fruits was continued at the Summerland Laboratory, 102 samples being examined. While a considerable improvement was noted over those packed in 1948, these products still showed excessively high bacterial counts, indicating the need for improved plant sanitation.

Studies were continued at Ottawa on the effect of freezing pure cultures of bacteria isolated from fresh products. Members of the *Serratia*, *Sarcina*, *Micrococcus* and *Flavobacterium* genera showed greater resistance to destruction by freezing that those of the *Bacillus*, *Lactobacillus*, *Clostridium*, *Aerobacter*, *Achromobacter*, *Escherichia* and *Chromobacterium* genera. Alternate freezing and thawing caused greater destruction than holding at a steady temperature. Species of moulds tested showed greater resistance than bacteria, both when frozen at a constant temperature and when subjected to alternating thawing and freezing.

Strongly positive tests for peroxidase in commercial products (which had shown a negative reaction immediately after blanching) prompted studies to determine the reason. Extensive tests with bacterial cells from 23 species ruled out any possibility that bacterial enzymes were responsible, and suggest that some other factor must be concerned.

Methods of preparing products for microbiological analysis have been compared. Products with few bacteria generally show good agreement between samples prepared in a Waring Blendor and those mechanically shaken. In high count products, however, results from the Waring Blendor method have shown greater variability than those from mechanical or hand-shaken portions.

Canned Fruits and Vegetables.—The examination of canned tomato products for mould content, carried out in co-operation with the Fruit and Vegetable Division, Marketing Service, was continued in 1949. A total of 2,318 samples were analysed in the laboratories at Summerland, Toronto and Ottawa. Of these, 18 per cent were above the established limits, as compared with 8 per cent in 1948. These results indicate that 1949 was one of the worst years for high mould count since records were started in 1935. Adverse weather conditions combined with inefficiency in sorting and trimming of the initial stock, are blamed for the generally higher counts.

Pickles.—To obtain information concerning their quality, a survey of pickles on the retail market was begun in co-operation with the Division of Chemistry and the Fruit and Vegetable Division, Marketing Service. Only 40 per cent of the samples of commercial brands of finished pickles were found to be of satisfactory quality, according to chemical, bacteriological and organoleptic tests. Pickles packed in Quebec were poorer in quality than those from other provinces. The lack of proper balance of salt, sugar and acid was found to be associated with poor quality. With the exception of three putrid samples which contained excessive numbers of bacteria, no correlation between microbial content and acceptability was observed. Sediment and filth analysis showed that a fairly high level of cleanliness was maintained by the packers.

Soil Microbiology

Soil Bacteria in Relation to the Growing Plant.—Previous studies of the "rhizosphere effect" of various crop plants have shown that in soil adjacent to the roots there is a preferential stimulation of organisms requiring amino acids for growth. The more specific amino acid requirements of the rhizosphere bacteria from clover, wheat and flax were investigated to determine which compounds may be responsible for the increase of this group of organisms within the zone of influence of the growing plant.

Of seven groups of amino acids, the sulphur-containing group (cysteine, methionine and taurine) was found to be of special significance, the omission of this group from a mixture of 23 amino acids resulting in a pronounced decrease in the percentages of organisms able to grow in a chemically defined medium. Further study showed methionine to be by far the most essential amino acid.

While evident in a striking manner for bacteria from the rhizospheres of all three crops, the effect was more pronounced in the case of clover than with wheat or flax. The results point to the availability of methionine in the rhizosphere and indicate the value of further work to elucidate the factors concerned with its occurrence, including excretion by roots, formation by decomposition of plant tissue, or elaboration by other micro-organisms.

Though the juices of certain plants are known to possess bactericidal properties, no information is available on the effect of the growing plants on the soil microflora. In tests with onion and garlic, both plants were found to exert a characteristic rhizosphere effect in stimulating the development of bacteria, actinomycetes and fungi in the soil adjacent to the roots. This was shown with respect to total numbers and numbers of different physiological groups of bacteria. However, there was evidence of a suppression of mirco-organisms on or in the root tissues, as distinct from soil adjacent to the roots, while certain groups, such as cellulose-decomposing and denitrifying organisms, were entirely absent. The results confirm that onion and garlic juices contain a very active bactericidal and fungicidal matter, but this is not excreted or diffused into soil in sufficient quantity to affect the activity of soil micro-organisms.

Soil Micro-organisms in Relation to Manganese Deficiency.—Previous reports have shown that the application of certain soil fumigants under field conditions gave a practical control of manganese deficiency disease of oats. However, it was noted that treatments with fumigants containing nitrogen in their composition not only corrected manganese deficiency, but also resulted in higher yields of grain and straw than did treatments with fumigants containing no nitrogen. Accordingly, the effect of nitrogenous fertilizers on the soil micro-organisms and availability of manganese in manganese deficient soil was studied. The results indicated that treatments with cyanogas (500 lb. per acre), calcium nitrate (175 lb. per acre) or ammonium sulphate (142 lb. per acre) resulted in the growth of plants free of manganese deficiency symptoms. The numbers of manganese-oxidizing, cellulose-decomposing and denitrifying organisms in the rhizosphere of oats growing in the treated soils were much lower than in the control plots. Statistical analysis of the data showed significant positive correlation between the severity of the disease and numbers of manganese-oxidizing organisms (0·9745), cellulose decomposing (0·7628) and denitrifying (0·6672) organisms. Furthermore, application of calcium nitrate and ammonium sulphate gave highly significant increases in yield of grain as compared with untreated plots.

The Microbiological Equilibrium in Potato Scab Infested Soil as Affected by Incorporating Cover Crops.—Further progress was made in co-operative studies with the Division of Botany and Plant Pathology at St. Catharines on the effect of incorporating soybean, rye and red clover in scab infested soil. Soybean alone reduced the incidence of disease. Soybean and red clover increased numbers of bacteria, actinomycetes and fungi, with rye stimulating all groups except actinomycetes. In soybean soil bacteria requiring amino acids were preferentially stimulated and those with more complex requirements relatively suppressed. When potatoes were grown in the soybean soil, bacteria requiring amino were markedly increased in the rhizosphere. In contrast, amino acid requiring fungi were completely suppressed in the soybean treated soil though increased in the rye soil. The "bacterial balance index" showed a relationship with the degree of scab infection, the high index in the soybean soil, and particularly in the potato rhizosphere, being associated with the least scab.

The Bacterial Population of Seeds.—Of the factors that influence the equilibrium of bacteria in soil there is ever increasing evidence that the effect of the growing plant is one of the most important. As part of a series of investigations

to consider also the rhizosphere effects and decomposition effects of six crop-plants—wheat, oats, flax, red clover, timothy and alfalfa—on soil bacteria, studies have been conducted to determine the qualitative nature of bacteria associated with seeds of these crops.

Morphological, physiological and nutritional studies were made on 2,130 isolates from the various crop-seeds. The results indicated that seeds contain a microflora which may be considered indigenous and that this population is characteristically different from that predominant in soil. Of special interest was the finding of specific crop-seed differences in the epiphytic flora, with relatively few types predominating on any kind of seed. More detailed taxonomic and cultural studies of these predominant organisms showed that twelve distinct bacterial types were prevalent on the various crop-seeds, and that in most cases each type seemed to be exclusively associated with the seeds of a specific crop. Having calculated the percentage incidence of each type with respect to the various crop-seeds, it was noted that three types were predominant only on wheat; one type formed the majority of bacteria on oats only; three types were specific for flax seed; three were found only on timothy seed, and one type only on alfalfa. One type, though predominant on the two legume seeds, was less specific in that it occurred to some noticeable degree on the seeds of oats, flax, and timothy.

Miscellaneous Investigations

Brood Diseases of Bees.—Extensive experiments on the influence of sulpha drugs and antibiotics on American foulbrood, carried in co-operation with the Bee Division, Central Experimental Farm, have been completed. The results show that both sodium sulphathiazole and sulphadiazine, when fed at the rate of 0·5 gram (7·5 grains) per gallon of 50 per cent syrup, completely prevented development of the disease in artificially-infected colonies. This sulpha drug effect could be reversed with para-aminobenzoic acid and by the purines, guanine and xanthine, but not by folic acid or methionine. These results indicate that the drugs prevent development of the disease by interfering with the purine metabolism of the bacteria since it has been found that *Bacillus larvae,* the causal organism, requires purines for growth. Procaine penicillin, clavacin, subtilin, bacitracin and aureomycin were ineffective in the apiary though very potent inhibitors *in vitro.* Spores of *B. larvae* suspended in one per cent sodium sulphathiazole for 16 months, and in 15 to 30 per cent of the drug for 7 months, were still virulent, as were those treated with Amosol or kept in moist soil for 7 months.

Experiments on age of susceptibility of honeybee larvae to American foulbrood were repeated during the summer of 1949. The results of the past year were confirmed, i.e. larvae were not susceptible beyond 54 hours. This was found to hold true for queen larvae as well as worker larvae.

Preliminary studies were made of the effect of two recently discovered antibiotics, aureomycin and chloromycetin, considered to have antiviral properties, in controlling sacbrood virus disease of honeybee larvae. These substances were fed to colonies in 50 per cent sugar syrup heavily inoculated with an extract of crushed larvae dead from sacbrood. The results showed complete protection of the larvae by these substances, whereas the control colony was heavily infected. Since few colonies were used in these experiments it is hoped to repeat them on a larger scale.

An aerobic spore-forming bacillus producing a reddish brown pigment and possessing strong dissociative tendencies was isolated from powdery scale of honeybee larvae sent in for examination by the Provincial Apiarist of Alberta. The organism was found to be a hitherto undescribed species and was named *Bacillus pulvifaciens.* It has not been definitely established whether this organism is a contaminant of dead larvae or the cause of their death.

Disinfectants.—Quaternary ammonium compounds have recently been introduced as germicides for use in dairy and food sanitation, this class of compound appearing to have certain advantages over the chlorine compounds commonly used for this purpose. A suitable test for evaluating the relative germicidal effectiveness of quaternaries is greatly needed, however, since the phenol co-efficient test, for many years the routine method for assessing germicidal effectiveness, does not give satisfactory results with these compounds.

Fundamental studies into the nature of the survivor curves of test organisms treated with quaternaries have revealed an unusual pattern of resistance. Instead of the straight line regression curve characteristic of the customary logarithmic order of death, quaternaires showed a sigmoid survivor curve. Further investigation revealed a wide range of resistance among the cells of the test organisms with a considerable proportion of cells unusually resistant to quaternaries. In such a situation, a test method based upon 100 per cent destruction of the test organism often fails to indicate the usefulness of a germicide which may destroy well over 90 per cent within the first minute.

By selective treatment with a quaternary, strains of test organisms have been selected which possess a more uniform resistance to this type of disinfectant so that "skips" in a test series are virtually eliminated. In view of the difference between phenol and the quaternaries in the shape of the death curve, it would be of advantage to use a disinfectant of the latter group as standard reference material. It is therefore proposed to establish a 'Hyamine coefficient', using Hyamine 1622 as standard, for the evaluation of disinfectants of the quaternary type.

Antibiotics and Antagonisms.—From 17 soil samples from Northern Canada, obtained through co-operation of the Division of Entomology, 660 strains of actinomycetes were isolated and screened for antibiotic action against five bacterial species *(Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis* and *Mycobacterium tuberculosis)* and three plant pathogenic fungi *(Helminthosporium sativum, Fusarium culmorum* and *Fusarium lini).* In all, 61 per cent of the isolates were found to antagonize from one to six of the test organisms with degrees of activity varying from slight to strong. The three pathogenic fungi were inhibited in varying degree, respectively, by 26 per cent, 15 per cent and 12 per cent of the actinomycetes. The total numbers of actinomycetes and the relative incidence of antagonistic types varied with the location of the soil and with the depth of the sample. Strains showing most active antibiosis, particularly against the soil-borne plant pathogens, are being studied in more detail for possible use in disease control.

In co-operation with the Division of Botany and Plant Pathology, work was initiated to determine the effect of known antibiotics on the internally-borne bacterial pathogens of beans, *Xanthomonas phaseoli* (common blight) and *Pseudomonas phaseolicola* (halo blight). Chloromycetin, streptomycin, clavacin, gliotoxin, aspergillic acid, tyrothricin, streptothricin, penicillin, polymyxin and aureomycin were tested and the last two found to cause complete inhibition at dilutions of 1:2,500,000 and 1:20,000,000 respectively. The first three compounds inhibited at dilutions of 1:320,000 and the next four at dilutions of 1:80,000 to 1:160,000. Tyrothricin had no effect on *P. phaseolicola* in this range of dilutions. This organism was more sensitive to streptomycin (1:10,000,000) than *X. phaseoli* (1:640,000) but was less sensitive to aureomycin, polymyxin, aspergillic acid and penicillin, which was much less effective on these gram negative organisms than the other antibiotics. Three quarternary ammonium compounds inhibited *X. phaseoli* at 1:160,000 and *P. phaseolicola* at 1:180,000, one such compound, Kleeneasy, being bacteriostatic at 1:640,000.

Bacteriophage for Identification of Bacterial Plant Pathogens.—In view of the importance of phage-typing as a diagnostic tool in bacteriology, work was started

in co-operation with the Division of Botany and Plant Pathology to apply this procedure for the rapid identification of *Xanthomonas phaseoli* and *Pseudomonas phaseolicola* in bean seeds. Bacteriophages were isolated from a mixture of leaf mould, soil, manure and sewage and were shown to be capable of lysing all strains of their homologous organisms but not others belonging to the same genera. The phage for *X. phaseoli* was so specific that it would not lyse the very closely related and culturally indistinguishable *X. phaseoli* var. *fuscans* or *X. phaseoli* var. *sojenis*. Isolations were made from macerated bean samples suspected of harbouring the disease and were exposed to phage. Cultures which were lysed were presumed to be either *P. phaseolicola* and *X. phaseoli* depending on the phage used; confirmatory evidence was obtained by demonstrating that only those cultures which were susceptible to phage were pathogenic to bean seedlings. By this means 4 out of 14 samples of beans were found to carry halo or common blight. A more rapid and efficient technique, based on the increase in number of phage particles at the expense of host cells in a suspected sample, has been evolved which showed 11 of 14 bean samples to be infected. This method is being further developed.

Production of Vitamin B_{12} by Micro-organisms.—In view of the importance of vitamin B_{12} in animal nutrition and the desirability of developing good sources of this factor for use in fortifying feeding stuffs, studies were commenced with the object of finding micro-organisms capable of synthesizing this vitamin. Screening tests were made on 266 bacteria and 676 actinomycetes for the detection of vitamin production. Of 126 bacteria isolated from soil with selective media, 79 were positive; of 92 organisms isolated from cow manure, 58 were positive; and of 48 bacteria isolated from various crop seeds, 23 were positive. Altogether, 60 per cent of the bacteria and 68 per cent of the actinomycetes studied were able, under the test conditions, to produce vitamin B_{12} in detectable amounts. The organisms showing the highest yields are being studied further to determine optimum conditions for production of the vitamin.

Services

The general analytical service was continued during the year, chiefly in co-operation with other divisions of the Department. This work entailed the examination of 17,654 samples, as compared with 18,801 during the previous year. Milk powders accounted for 11,933 samples, the remainder including other dairy products, frozen and dried egg (670), edible gelatine (1,683), canned, frozen and pickled vegetable and fruit products (2,339), honey (892), foulbrood specimens, legume inoculants and feeding stuffs. The work was carried out largely in connection with the control of agricultural products within the scope of Acts and Regulations respecting quality. In addition, 145 cultures for the inoculation of legume seed were prepared for Experimental Farms and Illustration Stations.

DIVISION OF BOTANY AND PLANT PATHOLOGY

The following account of the activities of the Division of Botany and Plant Pathology is almost entirely a progress report of the research work under way in the Division. It may be appropriate to indicate certain other activities. For example, most of the testing of new fungicides is carried out at the branch laboratories. In consequence, officers of the Division provide material assistance to provincial officials in revising the provincial spray calendars. Or again, in the annual provincial surveys for bacterial ring rot of potato, the examination of tubers from suspected cases is conducted at Division laboratories, notably those at Edmonton, St. Catharines, and Ottawa. Officers of the Division are

regularly consulted by officers concerning problems of disease in crops with which the latter are working. When the problem warrants investigation, further studies are often undertaken co-operatively. Also, many growers apply directly to the nearest laboratory for advice on the cause and control of any trouble noted by them in their crops.

Botany

Systematic Botany.—An outstanding feature of the year's work was the distribution of some 17,800 labelled specimens of Canadian plants to 92 botanical institutions in Canada and foreign countries. These specimens consisted of replicated material of native plants from northern Canada, the Ottawa district and various other parts of the country, as well as weeds and cultivated plants collected in previous years. The distribution was conducted on an exchange basis and in return much valuable material was forthcoming from other parts of Canada and from abroad. It is quite apparent from the response that authentic examples of the Canadian flora are greatly in demand by botanists in other countries, especially those in temperate regions. Besides providing a convenient means of obtaining useful comparative material of foreign plants from which most crop, forage and ornamental species, and other economic plants as well as weeds are derived, this exchange serves to establish closer relations with institutions abroad.

Field investigations in Northern Canada in co-operation with the Division of Entomology and under the auspices of the Defence Research Board were concentrated mainly in the Northwest and were augmented by the employment of university students and a specialist on Algae. Six regular staff members and six summer employees took part in the surveys.

Good progress was made in initiating a more thorough and comprehensive floristic survey of the vegetation of the prairie grasslands by field work of two members of the staff in southern Saskatchewan and Manitoba.

The usual service was provided to the public by way of identifying and supplying information on wild, medicinal, and cultivated plants. The development of this identification service and the increasing recognition of the Divisional herbarium have probably been responsible for the growing tendency on the part of amateur and professional botanists to submit their materials to the Division for verification and preservation.

Critical studies on Canadian plants have revealed that to date some 46 species, varieties, or forms require new or corrected scientific names. Some of these new and corrected names are in the process of being published, but others will have to await further study in the field and herbarium. An examination of the grasses preserved in Ontario herbaria also demonstrated that about 30 per cent of the specimens are incorrectly identified or filed under out-moded names.

The herbarium expanded rapidly during 1949, a total of 26,595 sheets being accessioned. This is the largest annual increment to date, greatly exceeding the 14,017 sheets added in 1948. The total number of specimens is now 128,109.

Over 1,000 plant specimens were collected in the Lower St. Lawrence region for the laboratory herbarium at Ste. Anne de la Pocatiere and duplicates of each collection were forwarded to Ottawa for insertion in the Divisional herbarium. The herbarium at present contains about 400 mounted specimens, representing 300 different species, and last summer's collection, when mounted will add more than 300 additional species, some of which are of economic importance.

A large number of weeds and native plants were identified at Saskatoon. Two hundred and fifty collections were made and sent to Ottawa for the Divisional herbarium. Duplicates of the rarer ones were added to the laboratory herbarium. Phenological data were recorded here and compiled for the three Prairie Provinces for inclusion in the Canadian Plant Disease Survey.

Phenological Observations in 1949.—At Ottawa, the 1949 season opened on April 6, with the flowering of silver maple, a date five days ahead of average for the species. Throughout spring and summer the season continued from three to four days earlier than average. The first dates of anthesis for marker plants at Ottawa in 1946, 1947, 1948, and 1949, together with the number of days that the 1949 observations depart from the average first date of anthesis, are given in the following table:

Marker Plant	1946	1947	1948	1949	Departure from average in 1949
Silver maple	March 21	April 12	April 5	April 6	6 early
American elm	April 7	May 6	April 22	April 22	4 early
Sugar maple	May 8	May 19	May 6	May 4	4 early
Scotch pine	June 1	June 10	May 30	May 25	4 early
Bitternut hickory	June 16	June 23	June 13	June 10	3 early
American basswood	July 10	July 18	July 10	July 3	4 early
Japanese knotweed	Sept. 4	Sept. 7	Aug. 28	Sept. 3	1 late
Witch hazel	Sept. 19	Oct. 6	Sept. 26	Sept. 19	9 early

Herbicide Registration.—The recent advance in the technical and commercial development of chemicals for weed control is reflected in the rapid increase in the number of applications for the registration of herbicides reviewed since 1946. Reviews in 1949 totalled 190, as compared with 131 in 1948, 91 in 1947, and 56 in 1946. The 1949 applications included 70 new products.

Products containing 2,4-D were represented in 1949 by 147 applications, divided as follows: sodium salts, 12; ester liquids, 43; amine liquids, 66; and dusts, 26. As in 1948, esters and dust preparations of 2,4-D have shown the greatest relative increase. Chemicals registered for the first time in Canada as herbicides were: pentachlorophenol in mineral oil, methyl bromide with chloropicrin, trichloroacetate, and borax.

Use of 2,4-D for Control of Weeds in Potato Fields.—A 2,4-D preparation containing 70 per cent of the sodium salt was used on a series of potato plots for the control of weeds. Various amounts of the product were applied at the rate of 120 gal. per acre when the potato plants were nearly ready to bloom. The dosages in 2,4-D acid equivalent per acre were 0·34, 0·59, and 0·84 lb. All treatments controlled the broad-leaved weeds, but it was clear that 2,4-D should not be used in seed potato fields because the leaf rolling and distortion it causes make it impossible to detect or rogue plants affected by disease. Moreover, all treatments resulted in yields lower than those obtained from the check plots, even though the weeds were permitted to grow in the latter. The decrease in yield varied with the concentration and variety from 4·5 to 19·8 per cent.

National Weed Committee.—The third western weed control conference, organized by the western section of the National Weed Committee, was held at Edmonton, Alberta, November 15-17. The conference was very successful and some 270 delegates attended. About half the papers dealt with the use of chemicals and the other half with the use of implements in the control of weeds. Relatively few new developments in the use of chemicals were reported, but specific recommendations as to the best stage of growth at which to apply the chemicals were given for certain weeds. The report of the herbicides committee, together with the report of the weed classification committee, will be a guide for the use of 2,4-D and certain other chemicals in the Prairie Provinces during 1950.

Weed Survey.—New developments in weed survey included a co-operative project in the Prairie Provinces with provincial departments of agriculture and

an extension of activities to Newfoundland. A number of other surveys were carried out in areas of Quebec and Ontario where the weed flora had previously been little studied.

As a new approach to weed problems, the Division at Ottawa organized a co-operative survey of the persistent perennial weeds of the Prairie Provinces. Funds were provided by the Department, the provincial departments of agriculture and universities supplied personnel and much of the supervision, while this Division was responsible for co-ordination.

Considerable progress was made in the first year. In Alberta, data on seven perennials were assembled from the records of weed inspectors, field supervisors, and others intimately acquainted with the weed situation. Maps have been prepared showing the location, and the degree of infestation of these seven weeds. Saskatchewan confined its survey to a field study of toad-flax and leafy spurge in two areas of the province. These weeds were found to occur over a far greater acreage than had been realized. Only 1,750 acres of leafy spurge had been located in the province up to March, 1949, yet in the more restricted survey area nearly 5,000 acres were found. Similarly, the acreage infested by toad-flax in the survey block of 1,700 square miles, is now known to be rather more than five times the 5,000 acres previously estimated for the entire province. In Manitoba, many hundreds of acres of leafy spurge were plotted in the Spruce Woods Forest area. Three townships in the Winkler area were surveyed for field bindweed and found to be heavily infested.

These surveys have shown that the persistent perennials are firmly entrenched on the agricultural lands of the Prairie Provinces and present a most urgent problem. Although this group of weeds is not responsible at present for as much loss as the annuals, the potential menace is far greater. The perennials are more localized than the annuals and their spread is largely by vegetative means. When once established, however, control is extremely difficult and usually more costly than the infested land is worth. Now that the control of annuals, biennials, and the less resistant perennials is rather easily and cheaply achieved by the used of selective herbicides, the control of persistent perennials becomes a problem of major importance.

In the Prairie Provinces, perennial sow thistle is at present in a period of increase following several comparatively wet summers. Sow thistle, common in fields to the north of Saskatoon, was observed to be replaced to a considerable extent by *Lactuca pulchella*, blue lettuce, to the south. *Axyris amaranthoides*, Russian pigweed, not commonly known by weed men, was present at every stop in Alberta and Saskatchewan but was less frequently observed in Manitoba. A collection of *Berteroa incana*, hoary alyssum, is the second record for Saskatchewan. *Scabiosa arvensis*, field scabious, can be added to the perennial weeds of Saskatchewan as the result of a collection to the north of Leask. An extensive stand of *Ambrosia elatior*, south of Morris, adds to the evidence that this annual ragweed is present in Manitoba.

A preliminary survey of weeds in Newfoundland was undertaken in late July and August. Full notes were made on the abundance and habitats of each species and these field observations are supported by 422 collections representing 125 species. These collections will serve as a basis for a Newfoundland weed list.

Cypress spurge, *Euphorbia Cyparissias*, is widely spread throughout Eastern Canada, generally as a graveyard escape. The root systems of cypress spurge and leafy spurge are very similar, as are other morphological characters, particularly the smooth, carunculed seeds. Leafy spurge is one of the serious perennial weeds of the West and its close relative may well be a potential threat in Eastern Canada. An attempt was made during the year to assess the status of cypress spurge in eastern Ontario and adjacent Quebec.

The largest infestation seen was at Braeside, Ontario, where the plant was grown in a garden about 1870 and apparently escaped before 1900. This stand of cypress spurge is probably one of the most extensive on the continent and almost certainly the largest in Ontario. Rapid advance has taken place in the last 15 years. The infestation extends northwestward from Arnprior to beyond Sand Point, a distance of six miles, and reaches inland from the Ottawa River for 1 to $1\frac{1}{2}$ miles. Several hundred patches were located and mapped within these limits. A total of 316 acres was found to be covered. The greater part of this acreage was in pastureland, with 11 acres on roadsides. On one farm of 129 acres, 50 acres of pasture were completely over-run by the spurge. Light soils prevail in the area and were the favoured habitat; only 11 acres of clay soils were found to be infested. Spring floods are blamed for the frequent patches along creeks. An infested gravel pit probably accounts for many of the numerous roadside patches. Many new sites were located in other areas, but few have as yet advanced beyond a single roadside patch.

Extensive collections and field-notes were made in the region about Shawville, Quebec. *Echium vulgare*, vipers bugloss, was found to be by far the worst weed, sometimes covering fields of 50 acres. *Potentilla argentea*, silvery cinquefoil, holds large areas on the lighter soils. *Brassica kaber* var. *pinnatifida*, wild mustard, and *Ambrosia elatior*, common ragweed, are extremely abundant. Important extensions were: four new sites for *Hedeoma hispida* in Quebec; and a new location for *Festuca octoflora*, the first record east of Alberta.

Further study was given to the infestations of *Echinops sphaerocephalus*, globe thistle, and *Onopordon Acanthium*, Scotch thistle, in the Goderich area, Ontario. This infestation of *Echinops* is the only large one in Canada. Apparently both plants have been well established at Goderich for 25 to 30 years. They do not appear to be spreading rapidly. A serious infestation of *Carduus acanthoides*, plumeless thistle, was discovered in Grey county, northwest of Owen Sound. This infestation covers several square miles and has rendered some fields almost useless for any purpose other than grazing by sheep.

The range of *Silene Cserei* can now be extended to Ontario and Manitoba. This aggressive catchfly was first collected in British Columbia, where it is now known from several localities, and, in 1948, Saskatchewan and Alberta were added to its range. Contrary to a recent monograph on *Silene*, nursery studies at Ottawa and field observations suggest that the plant is biennial rather than perennial. This catchfly is very similar to *Silene Cucubalus*, bladder campion, but differs chiefly in the non-inflated calyx. The seeds of *S. Cucubalus*, are 1·2 x 1·5 mm., markedly larger than those of *S. Cserei*, 1 x 1·1 mm.

Further Effects of Herbicidal Oils on the Physiology of Plants.—In an effort to elucidate further the mechanism of the selective action of herbicidal oils, investigations have been made on the effects of oils on the physiology of plants by means of the infra-red absorption apparatus.

Mustard plants are easily killed by a petroleum naphtha (boiling range 300-400°F). If a direct supply of water, however, is given to mustard leaves by floating them on water, the leaves remain alive and carry on photosynthesis and respiration after application of the oil. This result suggests that the oil affects the supply of water to the leaf cells of mustard plants. With tomato plants, which are very susceptible to petroleum naphtha, it was found that the transpiration of the untreated terminal leaflet of the fourth leaf from the base of the plant was decreased *(a)* 35 per cent when the oil was applied to the third or a more basal leaf and *(b)* 90 per cent when the oil was applied to the lateral leaflets of the fourth leaf, but its transpiration was not affected when the oil was applied to the fifth, or a more apical leaf. These results likewise indicate that petroleum naphtha interferes with the supply of water to the leaves of tomato plants.

To obtain further information on the action of oils on the physiology of plants, work was undertaken with a non-phytotoxic oil. The effects of this non-toxic oil on the photosynthesis, respiration and transpiration of attached leaves of parsnip and mustard were compared with those of a petroleum naphtha. It was found that the two oils immediately decreased photosynthesis and transpiration by both parsnip and mustard leaves, regardless of whether the oil was non-toxic or toxic. The non-phytotoxic oil did not however cause a permanent effect on the photosynthesis, respiration, or transpiration of mustard leaves as does a phytotoxic petroleum naphtha.

When tetrahydronaphthalene (tetralin), and unsaturated aromatic hydrocarbon, was added to the non-phytotoxic oil to give a 15 per cent solution of tetralin in the oil, the mixture gave approximately the same results for photosynthesis, respiration and transpiration of both parsnip and mustard leaves as did a petroleum naphtha. These results indicate that the addition of tetralin gives selective herbicidal properties to a non-toxic oil.

When different concentrations of tetralin in the non-phytotoxic oil were applied to mustard leaves the transpiration of those leaves receiving a 5 per cent solution of tetralin decreased 20 per cent while those leaves receiving 15 per cent solution decreased 90 per cent indicating that there was a relationship between the amount of aromatic present in the oil and the interference of the oil with the water supply to the leaves.

Although to date no work has been carried out on the possible direct chemical effect of oils on leaf cells, the above results suggest that oils interfere with the normal supply of water to the leaf cells, and that the selective action of oils on such plants as parsnip and mustard is due to differences in the way the oil interferes with the water supply to the leaves.

New Plant Physiology Laboratory at Lethbridge.—A new plant physiology laboratory planned at Lethbridge is now partially equipped and will soon be in operation. Preliminary studies were started in the field and greenhouse on growth relationships in winter wheat.

Cytogenetics of Agropyron.—Most study was given to meiosis in artificial intervarietal hybrids of *Agropyron trachycaulum.* Fourteen first-generation hybrid combinations have been grown. All of these showed slight to high meiotic irregularities. The degree of irregularity was not correlated with the varietal combination involved. Second-generation plants were less irregular and more fertile than the respective first-generation plants from which they had been derived by selfing. A study of the morphological variation in this species indicates that variation in a number of characters of potential taxonomic value cannot be correlated with the existing classifications.

Chromosome numbers of Grasses from Canada and South America.—Living plants and seeds were collected in Northern Canada and Newfoundland in the summers of 1948 and 1949. These have been grown and identified and the chromosome numbers of about 175 collections have been determined. The chromosome numbers of 148 collections of grasses made in South America in 1948 have been determined and herbarium specimens made of each collection.

Cytotaxonomy of Thistles.—A survey of the chromosome numbers in 6 genera of thistles was made in 1948-49, in connection with the weed investigations. This work was undertaken as a possible aid to the taxonomy of the genera. Basic chromosome numbers of the genera differ: Carduus 8, 10, 11; Cnicus 11; Echinops 16; Onopordon 17; and Silybum 17. Most species of Cirsium have $x=17$, but several were found to have unusual numbers: $x=10$, 11, and 13.

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Cytotaxonomy of Lobelia.—A cytotaxonomic study of North American species of *Lobelia* has been carried on for a number of years. The chromosome number of the species *Lobelia Cardinalis, L. siphilitica, L. puberula, L. glandulifera* is 2n = 14 with 0-5 supernumerary chromosomes; of *L. elongata* and *L. glandulosa*, 2n = 28 or 29. Intervarietal and interspecific hybrids have been grown and some study of meiosis made in an attempt to understand the phylogeny of the group. It is believed that *L. Cardinalis* and *L. siphilitica* are the most primitive species originating in the Appalachian area.

Ecology of the Wild Blueberry.—Work preliminary to a detailed ecological study of the species of *Vaccinium* in commercial fields of wild blueberry was begun in 1949 at the Blueberry Experimental Substation, Tower Hill, N.B. The botanical composition of vegetation of two areas typical of those from which blueberry fields are derived was determined prior to the application of any cultural treatments. The succession of plants following the planned treatments will be traced in subsequent years. Besides this ecological study, the diseases of blueberries are being investigated as part of a co-operative investigation with the Experimental Farms Service and the Division of Entomology.

Dominion Arboretum and Botanic Garden.—Planting of the native plant garden in the northeast portion of the Arboretum was begun in the spring of 1949 with the setting out of some 2,000 plants of local origin. Elsewhere in the Arboretum, 1,450 new trees and shrubs were planted in permanent locations. Propagation of trees and shrubs was continued: 2,642 packets of seed were sown; 4,500 cuttings of *Taxus, Juniperus,* and *Thuja* species and varieties, and 1,500 hardwood cuttings of deciduous shrubs were taken; 120 grafts were made.

Twenty-five numbers of Volume 4 of "This Week in the Arboretum", a weekly sheet containing information on plants in flower or of special interest during the spring and summer, were issued in 1949.

Plant Introduction and Seed Exchange.—The Index Semimum for 1949 listed 923 species and varieties of cultivated trees and shrubs, native and adventive Canadian plants, and commercial varieties of cereals, forage plants, garden vegetables, fibre flax, and tobacco. The Index was mailed to 374 botanic gardens, universities, and similar institutions in Canada and foreign countries in all parts of the world. During the year requests for plant material were received from 209 institutions in Canada and 40 foreign countries. In response, 9,160 lots of seed, plants, and cuttings were distributed. Through exchange, 2,713 similar lots of material were received from 116 sources in 41 countries. Much of this material was redistributed to Divisions of the Experimental Farms Service concerned with plant breeding. Surplus nursery stock from the nurseries of the Dominion Arboretum and Botanic Garden was widely distributed to branch farms and stations of the Experimental Farms Service, branch laboratories of Science Service, and new arboreta being established elsewhere in Canada.

Forest Pathology

Forest Mycological Collections.—During 1949, 923 additions were made to the collection of wood-inhabiting fungi in the Mycological Herbarium, Ottawa. These include 201 cultures for which neither specimens nor rots were received. The number of entries for this section of the herbarium now stands at 15,236. The specimens sent in for identification have increased considerably this year, 1,313 being received. Most of these were from the Laboratories of forest pathology at Victoria, Saskatoon, Toronto, and Fredericton, but specimens were also collected in Northern Canada and in the vicinity of Ottawa by the staff at Ottawa. Thirteen were received for indentification from Dr. E. O. Callen, of Macdonald

College. At the request of Dr. K. D. Bagchee, Forest Research Institute, Dehra Dun, India, 85 specimens of Polyporaceae were sent to him. The specimens received in exchange will be valuable additions to the herbarium. Mr. Wm. Bridge Cooke, of Pullman, Wash., requested the opportunity to examine the collections of *Cytidia, Cyphella, Solenia* and *Porothelium.* Notes concerning many of them were returned with the specimens. Collections of two new species of *Aleurodiscus,* including part of the type collection of each species, have been donated to the herbarium by Dr. H. S. Jackson, of the University of Toronto, and named specimens have also been received from Dr. J. L. Lowe, of the New York State College of Forestry, Syracuse.

Cultural Studies of Wood-Destroying Fungi.—With the addition of 178 cultures and the discarding of 91 others, the number of named isolates in the stock culture collection was brought to 1,601. These represent 463 species in 87 genera, of which 39 species and five genera are new to the collection. Of the additions, 27 were received from Dr. G. B. Rawlings, of the Forest Research Institute, Rotura, New Zealand. The majority of the remaining additions were isolated during field work in British Columbia last summer. The number of stock cultures still unidentified is 346, of which 26 were received from New Zealand. Series of monospore cultures are maintained for 51 named species and 20 unidentified isolates, numbering 1,541 cultures. The total collection of 3,488 cultures is stored at 10°C., together with a duplicate set of named stock cultures maintained under mineral oil at room temperature. In answer to requests from correspondents, 268 cultures were distributed.

During 1949, 1,710 cultures isolated from rots and stains encountered in decay studies on various tree species were submitted for identification by the Laboratories at Victoria, Saskatoon, Toronto, and Fredericton. Of these, 1083 belonged to species of Hymenomycetes and 931 or 85 per cent have been assigned to 27 species of Polyporaceae, 10 of Thelephoraceae, 3 of Hydnaceae, 4 of Agaricaceae, and one of Auriculariaceae. Of the 152 cultures of Hymenomycetes still unidentified some have yet to be examined and the remainder show cultural characters unlike those of any named species in the collection. Cultures of Fungi Imperfecti numbered 619 or 36 per cent; they included both stain-producing organisms and contaminants. Preliminary work in identifying these resulted in assigning 165 to genera and in some cases to species. The most important appeared to be species of *Cadophora.*

Of the cultures received from British Columbia, 114 isolated from decays in *Pseudotsuga taxifolia,* Douglas fir, were identified in 20 species of Hymenomycetes, including five species not previously encountered among isolates from this host, thus bringing to 29 the number of species isolated from this species. As in previous studies, isolates of *Polyporus Schweinitzii* were most numerous, numbering 48 or 42 per cent. One hundred and fifty-two isolates from decays in *Tsuga heterophylla,* western hemlock, belonged to 19 species of Hymenomycetes, three of which had not been isolated previously from decays in this host. This raises to 40 the number of species of which cultures have been isolated from this tree, *Fomes pinicola* having occurred the most frequently. The first decay study on western hemlock in the interior of British Columbia, yielded cultures of 15 species of which *Echinodontium tinctorium* and *Stereum sanguinolentum* occurred most frequently. Cultural identification of the fungi causing decays and stains in *Populus trichocarpa* is difficult. Only 34 isolates of Hymenomycetes, including 27 isolates of *Pholiota destruens,* and 38 cultures of *Fungi Imperfecti* of which 27 belong to three species of *Cadophora,* have been identified.

The 285 cultures received from Saskatoon included 111 isolates of *Fungi Imperfecti* and 174 of Hymenomycetes, of which 138 have been assigned to 16 species. *Polyporus circinatus* and *P. circinatus* var. *dualis* occurred most frequently among the isolates from *Picea glauca* and *P. mariana* and, as in 1948, only

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Stereum sanguinolentum was isolated from decay in *Abies balsamea* in Saskatchewan. Five isolated from decay in *Picea glauca* were identical with an unidentified species previously isolated only from decay in *Tsuga heterophylla* in British Columbia.

The 290 cultures submitted by the Toronto Laboratory were isolated from decays in *Picea* spp., *Abies balsamea,* and *Pinus Strobus* in Ontario. Of the isolates from spruce 79 have been assigned to 14 species of Hymenomycetes, those that occurred most frequently being *Fomes Pini* (21), *Corticium galactinum* (8), *Omphalia campanella* (8), *Polyporus circinatus* (8), *P. circinatus* var. *dualis* (8), and *Odontia bicolor* (7). Of the cultures from *Abies balsamea,* 125 have been identified in 13 species, bringing to 18 the number of species isolated from decay in this host in Ontario. *Corticium galactinum* with 32 isolates, *Stereum sanguinolentum* with 28, *Odontia bicolor* with 25, and *Poria subacida* with 9 occurred most frequently. Twelve cultures from decay in *Pinus Strobus* have been assigned to five species, and 23 isolates from *P. Banksiana* to 7 species, with *Fomes Pini* occurring most frequently in both hosts.

The first consignment of cultures from decay studies in New Brunswick numbered 336, of which 188 from *Abies balsamea* have been identified in 14 species of Hymenomycetes. *Stereum sanguinolentum* with 120 isolates (63%) ranked first in importance, with *Corticium galactinum* second with 39 isolates. Twelve cultures from decay in *Picea glauca* were identified in four species.

A summary of the fungi isolated from decays in the nine species of conifers on which most extensive studies were made in the period 1942-1949, shows that the majority of the isolates belong to only 35 species. Those that occurred most frequently were, in order of numbers isolated, *Stereum sanguinolentum, Fomes Pini, F. pinicola, Polyporus Schweinitzii, Corticium galactinum, Poria subacida, Polyporus circinatus,* and *P. circinatus* var. *dualis.*

Seven isolates from typical decays were shown by interfertility tests to be haploid cultures, belonging to four species. Interfertility tests were also used to verify identifications of isolates of *Fomes roseus, F. subroseus, Peniophora aspera,* and *Poria cinerescens.* Further interfertility tests on *Peniophora mutata, P. heterocystidia,* and *P. populnea* were carried out. Results indicate that *P. mutata* consists of two races, one including forms on *Populus* sp., the other including forms on other broad-leaved trees. Within each race there is complete fertility, but in crosses between the races only partial fertility or complete incompatability results.

Decay in Balsam Fir.—An investigation of the effect of decay on the management and utilization of balsam fir stands in New Brunswick was begun in 1949. The significance of this research is indicated by the interest, support, and excellent co-operation given by the forest services of several industrial and governmental organizations. Preliminary results have shown that relatively few fungi are responsible for the decay losses in balsam fir. Red heart rot, a trunk decay, caused by *Stereum sanguinolentum,* and a butt rot caused by *Corticium galactinum,* previously considered unimportant as a decay organism in balsam fir, together accounted for approximately 80 per cent of the decay in this species. Other miscellaneous fungi encountered include *Poria subacida, Coniophera puteana, Fomes pinicola,* and *Polyporus balsameus.* This project will be continued and expanded in 1950.

Balsam fir represents a large proportion of the merchantable volume of wood in the forests of Ontario and indications are that this species is likely to form an even larger portion in the future. It has been held in disfavour as a pulpwood compared with spruce. One of the principal reasons commonly given for not using it for pulp is that it is subject to comparatively large amounts of decay. Pathological studies were undertaken to provide accurate information about the decay and its relationship in this species.

A study of 933 balsam trees occurring in 19 quarter-acre plots located in three regions of Ontario was conducted concurrently with a deterioration study developed by American pathologists in budworm-killed timber during 1948. A definite relationship was found between age and decay. Balsam fir should be harvested before 80 years of age to secure the maximum volume of sound wood in the shortest time. On the basis of net increment, balsam fir should be cut at 7 to 8 inches D.B.H., which corresponds with the pathological rotation age of 80 years.

Of the balsam fir examined 38·7 per cent was infected with butt rot and 36·0 per cent with trunk rot. Of the total merchantable volume of all trees, 8·2 per cent was culled on account of butt rot and 23·5 per cent on account of trunk rot.

Fourteen wood-destroying fungi were associated with the decay of living balsam fir; of these, *Stereum sanguinolentum* and *Fomes pinicola* were responsible for practically all the trunk rot. An interim report on these preliminary findings has been prepared for distribution. Additional sampling areas were established during 1949 to study reported regional variations in cull losses.

Decay of Spruce.—Investigations of heart rot ordinarily involve the measurement of the reduction in net merchantable volume resulting from this defect. In Saskatchewan spruce, it appears that this type of loss is less important than the loss caused by wind-breakage and uprooting of trees that have been weakened by decay in the trunks, butts, and roots. The conventional method of felling trees by means of sawing them off above the root swell, fails to reveal the presence of decay below this level. In continuing this study in 1949, the trees were grubbed out by the roots. A high percentage of trees that were sound at stump height were found to contain advanced decay in the main roots. The study is being continued with the object of presenting pertinent information on root rot in a form in which it can be put to practical use by the forest industries.

Many instances were found in which root rot was associated with the work of boring insects. The Dominion forest entomologists are being consulted with the view to continuing this aspect of the project co-operatively.

Decay in Western Hemlock, Balsam Fir and Black Cottonwood.—Two studies, one on western hemlock and balsam fir in the Alberni Canal district and another on black cottonwood in the Quesnel area, were completed in 1949. In the former, it was found that the principal fungi causing root and butt rots were the same in both tree species. They were *Poria subacida, Fomes annosus, Armillaria mellea, Polyporus sulphureus,* and *P. circinatus.* In western hemlock the fungi causing trunk rots in decreasing order of importance were *Fomes pinicola, F. Pini, Stereum abietinum, Fomes Hartigii* and *Hydnum* sp. Similarly, in fir the fungi were *Fomes pinicola, Stereum abietinum, Hydnum* sp., *Fomes Pini and F. Hartigii.* Based on analysis of 963 western hemlock and 719 fir, it was found that, in the former, maximum periodic volume increment was reached between 225 and 275, and, in the latter, between 275 and 325 years of age. In both species, the principal avenue of entrance for the fungi causing trunk rots was wounds caused by snags or falling trees.

At the present time, the use of black cottonwood that yields the highest return is for facing seven-ply panels, and, for this purpose, the minimum diameter limit of trees that can be used economically is 18 inches at breast height. The specifications for peeler-grade logs are high and, as a consequence, the cull greatly exceeds the actual volume of decay. Difficulty has been experienced in determining the fungi that cause decay in this species. It has been established that the following four fungi cause a substantial amount of decay: *Pholiota destruens, Polyporus delectans, P. adustus* and *Fomes applanatus.* However, the fungi that cause the greater part of decay remain as yet unidentified. The majority of the infections were traced to branch scars and branch stubs.

During the year, investigations were begun on western hemlock in the Big Bend region of the Columbia River valley and near Terrace in the Prince Rupert forest district. At Terrace, in addition to data on hemlock, preliminary information was obtained on balsam fir, an associated species. In both regions, the decay losses were found to be excessive, causing about 50 per cent of cull at Terrace and 70 per cent in the Big Bend. It is evident that decay losses of this magnitude introduce serious problems in forest utilization.

Further studies were undertaken on the root rot of immature stands of Douglas fir and associated coniferous species, caused by *Poria Weirii*. Sample areas were investigated at Powell River to determine the effect of thinning operations on the progress and development of the disease.

White Pine Blister Rust.—Systematic studies were initiated in 1949 to determine the significance of blister rust in white pine stands in the Maritime Provinces. Permanent sample plots were re-examined to follow the progress of the disease on nursery stock. In New Brunswick, the disease appears to be prevalent throughout the range of the host, with 12 to 45 per cent of the trees infected in individual stands. In general, the disease does not appear to be so severe in Nova Scotia, where the percentage of diseased trees varied from 0 to 35 per cent.

Systematic surveys were continued towards the formulation of recommendations for the management of white pine stands in respect to blister rust in Ontario. In 1948, it was determined that only 3 per cent of the trees were fatally infected with blister rust in two valuable pine stands at the Petawawa Forest Experiment Station. The previous eradication work was thought to be an important factor in reducing the amount of blister rust in these areas. In 1949, a parallel survey was conducted in a pine stand in which no eradication work had been undertaken. In this instance, 4 per cent of the trees were fatally infected. Few *Ribes* were found in any of the above three stands. It is concluded that the incidence of blister rust in this area is not of sufficient severity to warrant the cost of a general *Ribes* eradication program. The scarcity of *Ribes* is very encouraging, as the Petawawa Forest Experiment Station is representative of one of the few areas suitable for the natural reproduction of white pine.

At the request of the Ontario Department of Lands and Forests, a blister rust survey was conducted in the Mattawa region. In this area, 12 per cent of the trees were fatally infected, a figure much higher than in the Petawawa area.

Decay of White Pine.—Studies designed to provide a knowledge of the relationships between decay and age, diameter, and rate of growth were begun in 1947 in Ontario and continued through 1948 and 1949. An interim report on these studies was circulated to forest authorities and industry in 1949.

During the course of these studies it became evident that *Corticium galactinum* may commonly occur as an organism responsible for butt and root rots of white pine. In view of the limited published information concerning the biology of *C. galactinum* and its pathogenicity, a study was made of the organism. The results of this work strongly suggest that, in addition to causing losses as a butt rot of living conifers, the fungus may be an important cause of mortality among young trees of several coniferous species.

Pole Blight of Western White Pine.—Pole blight, a disease of unknown cause and origin, was found to be prevalent and to be causing the death of an appreciable number of trees over most of the commercial range of western white pine in the interior of British Columbia. The disease appears to be confined to timber of pole size, approximately 60 to 100 years of age, and as a consequence, the present management policy of reserving such timber for future utilization may require modification. A co-operative project with the provincial forest service has been undertaken to determine the cause, progress, and control of the disease.

White Pine Needle Blight.—Needle blight is possibly the most conspicuous disease affecting white pine of all ages and in all localities. Although the injury has been known for many years, little research has been undertaken on the problem and the cause of the condition is unknown.

During 1949, the sample under continuous observation in Ontario was increased to include 6,430 trees on 44 sample plots. A re-examination of the plots established in 1948 showed a decrease in the intensity of needle blight from 19·3 to 12·5 per cent. As in 1948, more needle blight occurred in trees on the dry sites, viz., 4·1 per cent on moist sites and 14·1 per cent on dry sites. The reduction in the number of trees affected in 1949 occurred in the dominant and codominant crown classes, the number of intermediate and suppressed trees injured remaining approximately the same for the two years. On each site, many of the trees affected in 1948 showed no symptoms in 1949; on the other hand, a number of trees classified as healthy in 1948 revealed symptoms of needle blight in 1949. It may be noted that, according to the rainfall records at the Petawawa Forest Experiment Station, appreciably less rainfall occurred from June 15 to July 15 in 1948 than in 1949.

Mistletoe of Jack Pine.—Dwarf mistletoe is responsible for severe brooming, deformation, and premature death of jack pine. It is a heavy-seeded plant that spreads slowly from centres of infection. As far as known, it is confined to the Prairie Provinces. There is evidence that this parasite has been held in check by forest fires that have periodically destroyed diseased and healthy trees alike over large areas. Consequently, with the increasing efficiency of forest fire control in the more accessible districts, this disease may well become more serious. Investigations are under way to determine the eastern limits of its range and whether or not these limits are advancing eastwards.

Decay of Maple.—During 1949, the analysis was completed of the field data on decay of maple previously collected. Of 606 trees felled, and analysed for defect, about 80 per cent contained decay in varying amounts. Sixty-seven per cent of the trees were decayed at 80 years, 95 per cent at 200 years, and all trees over 220 years old had some decay.

Some 26 fungi have been shown to cause decay in living hard maples. However, nine species were responsible for 88 per cent of the known infections and for more than 90 per cent of the cubic volume of rot. They were as follows: *Armillaria mellea, Corticium vellereum, Fomes connatus. F. igniarius, Hydnum septentrionale, Pholiota adiposa, P. spectabilis, Polyporus glomeratus,* and *Ustilina vulgaris. Corticium vellereum* and *Pholiota spectabilis* have not been reported previously as the cause of decay in living trees of this species.

The courts of infection in decreasing order of importance were seams, dead branches and branch stubs, scars, and roots. Entry through seams accounted for 40 per cent of the the cubic volume of decay.

Deterioration of Birch.—A project in co-operation with the Ontario Department of Lands and Forests and the Division of Entomology was undertaken to determine whether or not die-back of birch occurs in Ontario. This disease has killed much of the birch in the Maritime Provinces. Twenty one-acre sample plots were established in representative stands, predominantly of yellow birch. occurring between Renfrew and Addington counties and the Nipissing district. Detailed records were obtained on 1,723 yellow birch and 325 white birch. The same trees will be re-examined annually. Near each plot, sample trees with varying degrees of twig injury were cut and examined for disease and for insect activity. Studies were conducted to determine whether or not the growth rate of these trees has been affected abnormally by meteorological or soil conditions.

From the localities investigated, it was evident that some of the yellow and white birch show symptoms similar to die-back as it occurs in the Maritimes. However, these symptoms neither occurred to an alarming extent nor was there any uniformity in their incidence.

A study of the fungus flora of dead and dying birch was undertaken at Ottawa in connection with the field studies in Ontario. A total of 1,393 samples from 88 trees of *Betula lutea*, yellow birch, were received for culturing. These trees were located on 14 sample plots set up in 6 counties. The samples ranged in size from small twigs with dead or dying foliage to sections of large branches. Sections from twigs, branches, and foliage were cultured, the cultures being made mainly from cankers.

The fungi from yellow birch proved to be quite similar to those found in the Maritime Provinces in 1948. The most common fungus was a *Phomopsis* sp. which was isolated from samples of 83 of the 88 trees. This fungus was isolated consistently from definite cankers or diseased areas on twigs, branches, branchlets, foliage, and buds. Two other commonly occurring fungi were *Coniothyrium* sp., isolated from samples of 79 trees, and *Melanconis nigrospora* on dead twigs of samples from 63 trees. Other fungi isolated repeatedly, but not consistently, included *Gelatinosporium magnum, G. fulvum, Asterosporium betulinum, Diatrypella betulina, Cytosporina* sp., *Libertella* sp., *Melanconium betulinum*, and several unidentified species.

In addition to the above detailed investigation, a general mycological study was made on samples from 282 trees from 6 sample plots set up to test the effects of thinning on birch die-back. Four of these plots were located at the Petawawa Forest Experiment Station, and two at Dorset. Of these 282 trees, 81 were yellow birch, and 201 *Betula papyrifera.*, white birch. Ten twigs from each tree were cultured and it was found that the mycological picture for white birch was quite different to that found in yellow birch. In white birch the most commonly occurring fungi obtained in culture from disease lesions on living tissue were *Melanconium bicolor*, and an unknown fungus, tentatively placed in the genus *Sphaeropsis*. The fungi most commonly found fruiting on dead twigs were *Cryptosporella* sp. and *Steganosporium* sp. Several species of fungi, as yet unidentified, were found repeatedly, but not consistently, fruiting on the twigs or were isolated in culture.

Dutch Elm Disease.—As before, work on this project was carried on cooperatively by the federal Department of Agriculture (Divisions of Botany and Plant Pathology, Entomology, and Plant Protection), the Quebec Department of Lands and Forests, and the Ontario Department of Agriculture.

In Quebec, scouting was confined to the outer sections of the general area of infection and this limitation of the area surveyed resulted in a substantial decrease in the number of collections made. The disease has now become so well established in the central part of the infected area that further efforts to control it there, except in towns and cities, seemed inadvisable. However, the removal of infected trees as a control measure was continued in the outer sections of the affected area. In the western part of this area, there was considerable intensification of the disease in some of the counties bordering the Ottawa River. In Two Mountains, for example, 110 infected trees were found in 1949 and 8 in 1948, the corresponding figures for Argenteuil being 26 and 11 and for Vaudreuil 8 and 0. There was some extension of the area of infection to the south, diseased trees being found in two border counties, Mississquoi and Stanstead, for the first time. In the former, infected trees occurred within 3 miles of the Vermont border and, in the latter, within 8 miles of the New Hampshire border.

In eastern Ontario, a single infected tree was discovered in Ottawa in 1948 and positive cultures of the fungus that causes the disease were obtained from

13 dead or dying trees in six counties. In view of this, the scouting staff in Ontario was increased in 1949 and instructions were given to pay particular attention to the examination of elms in the vicinity of the 14 trees mentioned. Although that part of the province east of a line approximately from Kingston to Pembroke was carefully surveyed, not a single instance either of a diseased tree or of the causal fungus existing as a saprophyte in dead wood was found. From a consideration of the results obtained in this region in 1948, it was expected that at least some infected trees would be found there this year and it is difficult to account for the complete absence of the disease. However, the increase in the number of infected trees in several counties in Quebec just across the Ottawa River from Ontario makes it imperative to continue to maintain a close check on conditions in eastern Ontario.

Deterioration of Fire-Killed Pine.—Large areas of red, white, and jack pines of commercial size were killed by fire in the Mississagi region of Ontario during 1948. Forest authorities in Ontario viewed this situation with apprehension, as a large portion of the dwindling reserves of white and red pine in this province is in this region. The Toronto Laboratory was requested to investigate the deterioration of this timber in order to provide information useful in salvage operations.

In collaboration with field officers of the Forest InsectLaboratory, Sault Ste. Marie, a detailed study of the fungi responsible for deterioration of fire-killed trees was commenced in the summer of 1949. Sample trees which represented the different types of fire damage were located, felled, dissected, and examined for decay. It was discovered that in no case were the deteriorating effects of fungi sufficient to result in a degrading of logs. Insect activity, on the other hand, was very prevalent and appeared to be the limiting factor governing possible salvage operations. A blue-stain fungus was found to be associated with the tunnels of wood-boring larvae, but fungus activity could not as yet be considered a factor in deterioration. Further studies may be conducted to determine the progress of deterioration in the fire-killed trees if it is found advisable to cut large volumes of poor grade lumber.

Deterioration of Insect-Killed Balsam Fir.—Large areas of balsam fir of commercial size have been killed as a result of attack by the spruce budworm. Since 1946 field officers of the Forest Insect Laboratory, Sault Ste. Marie, have carried out a study of the insect species associated with the death and deterioration of balsam fir killed by the spruce budworm west and southwest of Lake Nipigon. Detailed tree records of special study plots and permanent mortality plots established in 1943, have been maintained during each year of the study. Trees in these plots began to die as early as 1944; by 1949, some 300 trees, for which accurate dates of death were known, were available for sectioning studies. Blocks taken from dead trees at intervals of eight feet, were examined in detail for deterioration causes both by insects and fungi.

Polyporus abietinus, the cause of a white rot, was the most important deteriorating agent in balsam fir killed by the spruce budworm. It was responsible for over 95 per cent of the loss. The only other fungi of any consequence were *Fomes pinicola, Lenzites saepiaria,* and *Fomes roseus,* all of which cause a brown rot.

No loss from deterioration occurred within one year of the death of a tree, although incipient decay by *Polyporus abietinus* had already appeared in a large number of trees. Deterioration was progressive and trees examined four and five years after death showed losses of over 40 per cent. Gross losses at this time, however, were much greater owing to breakage and windfall. No consistent trends were evident when trees were segregated according to the time of year at which death occurred.

The rate of deterioration of balsam fir in budworm-killed stands must be considered in the light of other physical and economic considerations in its application to salvage. Although wood affected by the brown rots cannot be used in pulping, it would appear that wood not too seriously decayed by a white rot organism, such as *P. abietinus*, may be used in the sulphite pulping process. Balsam fir trees that have been dead for more than three years are unsuitable for salvage.

Hail Injury to Forest Stands.—The Saskatchewan Department of Natural Resources requested an investigation of a spike-top condition in white spruce in the Candle Lake Provincial Forest. Large trees were killed back from the top, down to diameters of 4 inches and more. Numerous symptoms led to the conclusion that this damage could only have been caused by hail in the latter part of the growing season of 1943. This conclusion is supported by meteorological records for Prince Albert, which indicate that severe hail storms occurred in the region on August 27 of that year. In addition to the spruce, poplar and jack pine were damaged, the latter so severely that all the trees in a wide strip through a pure stand were dead, giving the appearance of the effect of a severe ground fire. The bombardment of hailstones appears to have been so heavy as literally to have pounded the bark off parts of the upper trunks and branches on the windward side, and to have caused numerous wounds in the heavier bark of the lower portions.

Smelter Fume Injury.—The brief annual inspections of the condition of trees and shrubs in the Sudbury district, which have been made during the past several years, were continued. In August, a period of ten days was occupied by this examination. Owing to the abnormally low precipitation that prevailed during the growing season of 1949, the foliage of broad-leaved trees and shrubs became discoloured prematurely. By mid-August, many of the leaves of birch, willow, cherry, hazel, and bracken had turned yellow. As usual, this effect was most common where the plants occurred in thin exposed soils. Needle blight of white pine was not nearly so prevalent in general as it was last year, although it was common in certain locations. In those parts of the Temagami Forest Reserve that were examined, there was a definite decrease in the number of pines affected by blight. The appearance of the conifers generally in the Sudbury district was greatly improved, as compared with last year when winter injury was common. Although many trees, particularly white pines, were severely damaged by winter injury in 1948, no mortality from this cause was observed. In the French River District, it was found that 14 per cent of the white pine was affected by blister rust. The three tagged groups of white and red pines, located in widely separated parts of the district, which are examined annually for possible effects of sulphur dioxide, were all found to be in good condition with the exception of two trees in the group on Bear Island in Temagami Lake. One of these was severely affected by needle blight when selected in 1946 and had died since the examination of 1948. The other in the same group was in poor condition, but the symptoms were not those of sulphur dioxide injury. The drought that occurred during the summer of 1949 created conditions that were unfavourable to the occurrence of injury by sulphur dioxide. No acute injury was observed at any considerable distance from Copper Cliff, although several local points were severely affected. Acute injury in birch, aspen, bracken, and other species was noted between Wanipitei and Sudbury, in Garson township, and west of Wanipitei Lake along the Poupore road not far from Skead.

Mycology and Miscellaneous Projects

Plant Disease Survey.—The more important observations on the occurrence of plant diseases in Canada in 1949, except certain tree diseases, are reviewed briefly below.

The only cereal rust in Canada that was sufficiently prevalent to cause appreciable damage in 1949 was leaf rust *(Puccinia triticina)* of wheat. It appeared in Manitoba in late June and spread rapidly into eastern Saskatchewan. The actual damage it caused was not determined, but it is known that severely rusted crops ripened prematurely with the onset of very hot weather in early August and gave disappointing yields. Redman wheat was attacked almost as heavily as Thatcher and, in general, the Hope and H44 derivatives grown in the rust area of Manitoba and eastern Saskatchewan were susceptible to the races present there. In some other parts of Canada, these wheats remained moderately resistant, whereas the principal varieties grown were heavily rusted.

The only noteworthy change this year in the prevalence of cereal smuts in the Prairie Provinces was an increase in loose smut of barley. Fields with 10 to 18 per cent loose smut were common, the average for all fields examined during a survey made by the Winnipeg laboratory being slightly over 3 per cent.

The seed-drill survey of coarse grains in Manitoba begun in 1947 was carried out again in 1949 in co-operation with the provincial extension service. A total of 377 samples of barley and oats were collected in 21 districts of the province and examined for smut spores. The crops grown from these seed lots were examined before harvest for smut. All the lots of seed carried smut spores; 28 per cent had only a trace of smut and the crops they produced contained an average of 0·26 per cent smutted plants. The remaining seed lots had light to heavy spore loads and produced crops with an average of 1·34 per cent smutted plants. Some 50 per cent of the seed lots were sown untreated, 20 per cent had been treated with Ceresan, 16 per cent with Leytosan, 10 per cent with formaldehyde, and 4 per cent with other disinfectants. The average percentages of smutted plants in the resulting crops were 1·57, 0·30, 0·39, 1·20, and 0·25 respectively.

Dwarf bunt (race of *Tilletia caries)* of wheat was again found in British Columbia, mostly around Armstrong.

In Saskatchewan, 289 fields were surveyed for root diseases, of which 245 were in wheat. Take-all *(Ophiobolus graminis)* was severe in some fields in the Snowden area. On the other hand, common root-rot was present in all wheat fields surveyed. The mean disease rating was 13·4, the highest since comparable data were collected, the lowest recorded being 6·0 in 1942. Premature blight, a phase of the same disease, was severe in northeastern Saskatchewan; some wheat fields showed 30 to 40 per cent of the crop affected. Common root-rot also appeared to be more prevalent than usual in Alberta and Manitoba.

Eye spot *(Cercosporella herpotrichoides* Fron) was found affecting a sample of winter wheat from a field in Durham county, Ontario, which was severely diseased. Eye spot has not previously been reported in Canada, but it has become a disease of considerable importance in England since its discovery there in 1935.

Seed sterility caused by a fungus identified as *Podosporiella verticillata* O'Gara was found in trace amounts in 11 samples of common and durum wheat in an area from Assiniboia, Sask., to Edmonton, Alta. This rare fungus has not been previously recorded in Canada.

The finding of bacterial wilt *(Corynebacterium insidiosum)* of alfalfa well established in eastern Ontario suggests that the disease will eventually be recognized wherever alfalfa is grown in Canada. A modification of the method used in the identification of bacterial ring rot of potato has proved useful in determining the presence of *C. insidiosum* in root tissues of alfalfa.

A rarely recorded disease, bacterial stalk rot *(Erwinia dissolvens),* caused the death of 10 per cent of the plants in one inbred corn planting in Essex county, Ontario. Stalk rot due to *Giberella Zeae* caused heavy losses in yield in southern

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Ontario. Although the perithecia of *G. Zeae* are found on overwintered corn stalks in Manitoba, ascospore development and discharge appear to occur too late in the area to cause appreciable head blight of cereals. Corn smut *(Ustilago Maydis)* was exceptionally abundant in southwestern Ontario.

Due to decreased flax acreage in Manitoba and Saskatchewan, flax is now grown in fields so widely scattered that there is little spread of disease from field to field, although an individual field may be moderately affected. Seedling blight *(Rhizoctonia Solani)* of flax appeared most severe on land that was cropped to barley the previous year. For a second year *Alternaria linicola,* a common pathogen of flax seed in Western Canada, was isolated from brown stem lesions; symptoms of the disease were also readily reproduced this year in the field by spraying flax in the early boll stage with spores of *A. linicola.* Although infection was nowhere heavy, rust *(Melampsora Lini)* was present in scattered fields of Dakota in Manitoba, whereas the variety was free of infection in 1948. Severe damage to Dakota may be expected in the future. That flax growing in Manitoba and Saskatchewan is dependent on varieties resistant to wilt *(Fusarium oxysporum* f. *Lini)* was clearly demonstrated on a farm where 20 acres of Crown were sown to complete a field of Dakota; the Crown was almost completely killed by wilt, whereas only traces developed in Dakota. Pasmo *(Mycosphaerella Linorum)* was found definitely affecting fibre flax at Guelph, Ont.

Pod and stem blight *(Diaporthe Phaseolorum* var. *Sojae)* became epidemic in some soybean varieties in southwestern Ontario. Brown stem rot *(Cephalosporium gregatum)* was present in many fields of the variety Hawkeye. Manganese deficiency was general in soybeans and in some fields it impaired quality and reduced yield.

Bacterial ring rot *(Corynebacterium sepedonicum)* of potato proved unusually prevalent in Canada in 1949. This up-surge of ring rot may be accounted for by the hot, dry weather during a large part of the season. Experiments in 1937 indicated that such weather was unusually favourable to the development and symptom expression of the disease. Late blight *(Phytophthora infestans)* of potato was of little importance in 1949. Over most of Canada the summer was hot and dry. Frequent rains and cooler weather favoured blight development in September, but losses from tuber rot were generally light, except in Prince Edward Island. The present low incidence of leaf roll (virus) both in seed-potato and table-stock fields is attributed to the extensive use of DDT in the principal potato-growing areas.

A new seedling blight *(Fusarium oxysporum)* of asparagus is described from the Niagara Peninsula, Ont. Mosaic (virus) affected a high percentage of the plants in 30 acres of beans grown in British Columbia from imported seed. For the second year Arasan was used successfully to control wire stem *(Rhizoctonia Solani)* in cabbage in Quebec. Violet root-rot *(Rhizoctonia Crocorum)* was found for the first time in Ontario; it appeared to be fairly prevalent on carrots in the Thedford area in Lambton county. Carrot roots supplied with an adequate amount of boron during the growing season in interior British Columbia suffered a 5 per cent loss during storage from black rot *(Alternaria radicina)* compared with a 25 per cent loss in roots grown in soil in which the supply of boron was low. Although whiptail of cauliflower is an uncommon disease in Canada, some evidence is presented that its occurrence here, as in New Zealand and Australia, is due to molybdenum deficiency. A new root-rot *(Pythium irregulare* Buism.) of onions, known locally as yellow patch, has been observed in southwestern Ontario. Yellow dwarf (virus) continues to be destructive to the onion seed industry in British Columbia. Observations made in Manitoba indicate that bacterial blight *(Pseudomonas pisi)* is one of the important seed-borne diseases affecting pea production in that province.

Fire blight *(Erwinia amylovora)* was more serious than for many years on pear and apple trees in the Okanagan Valley and the Kootenays, B.C. Apple

scab *(Venturia inaequalis)* was relatively heavy in the Salmon Arm district, B.C., but was very light in most other parts of Canada. Perennial canker *(Neofabraea perennans)* again increased in prevalence in the Okanagan Valley; this increase is due to the killing of parasites of the woolly aphis by the new insecticides. Since the introduction of a sprinkler system of irrigation in the Okanagan Valley, rot *(Phytophthora Cactorum)* has affected the fruit on the lower branches of pear trees.

Coryneum blight *(Clasterosporium carpophilum)* caused much less damage to the apricot crop in the Kootenays owing to the wide adoption of the recommended spray program. Little cherry (virus) is still absent in the Okanagan Valley, but in the Kootenays only a few cherry orchards are unaffected. Cherry virus diseases continue to be serious in the Niagara Peninsula, Ont. Brown rot *(Sclerotinia fructicola)* caused no loss in the Okanagan Valley, B.C., in contrast with 1948, and it was of minor importance in the Niagara Peninsula, Ont.

Leaf blight *(Dendrophoma obscurans)* of strawberry became prevalent in Ontario late in the season. Considerable varietal differences were seen in the resistance of strawberries to leaf scorch *(Diplocarpon Earliana)*. *Gnomonia Fragariae* Kleb. var. *fructicola* Arn. and its pycnidial stage, *Zythia Fragariae* Laibach, were isolated from a leaf blotch at Ottawa. This is the first report of the fungus in Canada, but the blotch has probably been confused previously with other leaf diseases. Its importance as a pathogen is still in doubt. Red stele *(Phytophthora Fragariae)* was found for the first time in New Brunswick. Yellows (virus) is severe and general in plantings of Marshall in coastal British Columbia. Root-rot (cause unknown) caused heavy losses in several districts.

Poria obliqua was found to be the cause of heart rot of *Betula papyrifera* var. *communtata* in British Columbia. Die-back (cause unknown) of birch is now ubiquitous in the Maritime Provinces. Cone rust *(Chrysomyxa Pyrolae)* was unusually heavy on *Picea Engelmanni* and *P. glauca* var. *albertiana* in British Columbia. Leaf rusts *(C. ledicola* and *C. Empetri)* were heavy on white and black spruce in northern Quebec. Shoot rust *(C. Woronini* Tranz.), hitherto unrecorded in the new world, was found on *P. glauca* in northern Quebec and on the alternate host, *Ledum palustre* var. *decumbens* in the Yukon. Needle blight *(Hypodermella concolor)* was heavy on *Pinus contorta* var. *latifolia* in parts of British Columbia, and canker *(Phomopsis lokoyae)* caused considerable damage to Douglas fir at two places in that province.

Rust *(Puccinia Millefolii*, formerly reported under the synonym *P. Ptarmicae)*, was again heavy on *Achillea Ptarmica* in eastern Quebec. Downy mildew *(Peronospora Antirrhini* Schroet.), a new disease for Canada, was found on cultivated snapdragons in Ontario. Core rot *(Sclerotinia Gladioli)* caused losses of 65-95 per cent in several gladiolus varieties stored at Norwich, Ont., after inadequate curing. Severe injury to gladiolus corms from naphthalene fumigation occurred at Ottawa. Powdery mildew *(Oidium* sp.) caused heavy loss of hydrangeas in a greenhouse at Toronto, and stem rot *(Sclerotinia sclerotiorum)* destroyed most of a shipment from British Columbia to Ontario. Rust *(Cumminsiella sanguinea)* was found on *Mahonia Aquifolium* in eastern Quebec, the first report of it in eastern North America. Decline (virus) of narcissus is widespread in British Columbia; although known for some time under various names, it has not been previously reported in the Survey. Leaf and stem blight *(Helminthosporium Portulacae* Rader) was found in Ontario on *Portulaca grandiflora* and in Saskatchewan and Quebec on the weed, *P. oleracea*.

Mycological Herbarium.—In 1949, 764 specimens were added to the general herbarium, exclusive of mushrooms and wood-destroying fungi. Of this total, 455 were received in exchange and the remainder were sent in for determination or were collected by members of the Division. Many more specimens were collected and determined, but awaited labelling and entering at the year's end.

The fall of 1949 favoured the development of fleshy fungi in the Ottawa district and intensive collecting of Agaricaceae and Boletaceae (413 specimens) and Gasteromycetes (122 specimens) was done. These collections included 58 new records. Many specimens were brought in by the public for identification.

Mycological Studies.—A paper was published on the species of *Tympanis* occurring on pines. Studies nearing completion or in press include: a world monograph of the genus *Tympanis*, the genus *Chrysomyxa* in North America, a new grass rust, and the rusts attacking *Armeria* and *Limonium* in North America. Studies of several other groups of fungi are under way. Progress is being made in the study of parasitic fungi from Northern Canada.

Sexuality Studies on Fusarium.—Studies on the sexuality of *Fusarium sambucinum* form 6, the fungus mainly responsible for dry rot of potato tubers in Canada, have shown for the first time that two mycelia of opposite mating type are required for the production of fertile perithecia. Single ascospore or single conidial cultures of this fungus are bisexual (hermaphroditic) but self-sterile.

Crosses made between monosporous cultures of opposite mating type of *F. sambucinum* f. 6 and *Gibberella cyanogena* (Desm.) Sacc. have readily yielded fertile perithecia morphologically identical with the perithecia formed when appropriate strains of *Fusarium sambucinum* f. 6 are mated. *Gibberella cyanogena* is, therefore, considered to be the perfect stage of *Fusarium sambucinum* f. 6.

Basic Studies on the Action of Fungicides.—In a previous investigation it was shown that, of the four dithiocarbamates commonly used as spray materials, Dithane is more fungistatic than Parzate, Fermate, or Zerlate, but that its fungistatic life is much shorter. In the present studies, when the decoloration of starch-iodine agar by water suspensions of the salts was used as an index, it appeared that they break down at different rates with the evolution of hydrogen sulphide. Among the salts not yet sold as spray materials, manganese ethylene bisdithiocarbamate appeared to behave like Dithane, and manganese dimethyl dithiocarbamate like Fermate. The fungistatic value of iron ethylene bis-dithiocarbamate appeared to be slightly below that required of a useful fungicide, and copper dimethyl dithiocarbamate proved much too stable to offer any promise as a spray material.

Effective field sprays have been compounded by adsorbing malachite green on Norit (carbon black) and on Bentonite clay. Preliminary results show that a spray consisting of equal quantities by weight, 0·5 lb. of each per 100 gl., is effective against powdery mildew of apples. The Norit reduced the concentration of soluble malachite green from ·05 per cent to ·01 per cent and thereby provided an insoluble residue on the foliage, which prolonged the effectiveness of the malachite green.

Diseases of Cereals

Cereal Rusts.—The distribution of physiologic races of leaf rust of wheat in 1949 did not differ appreciably from that of the previous year. Race 58 predominated in Eastern Canada. In Manitoba and Saskatchewan, races 5, 15, and 126, which are virulent to wheats of Hope and H44 parentage, were present almost to the exclusion of other races. Together they accounted for about 70 per cent of all the isolates from leaf rust collections made throughout Canada in 1949. These races were present in southern Alberta and British Columbia, but they occurred there less frequently than races 1, 11, and 33. The source of much of the leaf rust in these regions is believed to be different from that of the leaf rust found in the eastern part of the prairie region. Its place of origin may be the Palouse area of Washington and Idaho.

In 1949, a reduced set of differential hosts, agreed upon by Canadian and United States rust investigators, was used to differentiate races of leaf rust.

A complete explanation of the origin of the many new physiologic races of leaf rust of wheat that have recently been encountered must await further experiment, but some aspects of this problem have been studied at Winnipeg. One of the possibilities investigated was that of nuclear exchange between the mycelia of different races in the uredial stage. Infection studies with mixtures of races 9 and 15 and of races 5 and 9 did not yield any evidence that these races could interchange nuclei and thus initiate new pathogenic strains of leaf rust.

Another way that new races of leaf rust may arise is through the recombination of rust nuclei on the alternate host *Thalictrum*. In infection tests in the greenhouse with native species, aecia were produced on *T. dasycarpum*, pycnia only on *T. dioicum* and *T. polybamum*, but no infection occurred on *T. venulosum*. Under out-of-doors conditions, infection tests on *T. dasycarpum* and *T. venulosum* yielded negative results. Two introduced species, *T. glaucum*, and *T. dipterocarpum*, produced abundant aecia when inoculated in the greenhouse and *T. glaucum* reacted similarly when inoculated out-of-doors.

Selfing studies in which *T. glaucum* was infected with known physiologic races, indicated that some races of leaf rust are homozygous and others heterozygous for pathogenic characters. A culture of race 3 was heterozygous, giving rise to races 3, 15, 32, 68, and three undescribed races. A culture of race 76 was heterozygous for both pathogenicity and urediospore colour. Aeciospores derived from teliospores collected in the field gave rise to uredial strains of yellow spore colour. Most of the yellow rust strains were decidedly low in pathogenic vigour.

No significant changes have been noted in the last year in the prevalence of races of the wheat and oat stem rusts in Canada. Race 56 is still the most common race of wheat stem rust, accounting for 69 per cent of all isolates. Races 38 and 17 come next in order of prevalence.

The rye variety of stem rust, which can attack both rye and barley but which is not usually considered to be of much importance on barley, was found in 1949 to be responsible for a heavy infection on Vantage barley at Fredericton, N.B. This variety is resistant to wheat stem rust. In future, it may be necessary to pay more attention to the reactions of barley varieties to rye stem rust.

Changes that affect the reactions of certain oat varieties appear to be taking place in crown rust of oats. Prior to 1948, races of this rust that attacked Bond and Clinton were rare. In that year, races 34, 45, and 57, three races that attack these varieties, became quite common and comprised about 20 per cent of the crown rust collections made in Canada. This year, there has been a further increase in the prevalence of these races and they now account for nearly half of the crown rust found in Eastern Canada and Manitoba. As a consequence of the rusting of Bond and Clinton, plant breeders are now using the varieties Landhafer, Santa Fe, and Trispernia as sources of crown-rust resistance.

Rust-resistant varieties of wheat and oats have been widely grown in Western Canada for about 12 years, a period long enough to permit an analysis of their effect on rust epidemiology in that region. It is now evident that the substitution of the rust-resistant varieties for susceptible ones has reduced the number of stem rust spores present in the air over Western Canada. Furthermore, stem rust of wheat no longer spreads as far northward and westward as it did before the introduction of resistant varieties. Reduction in the number of spores of wheat stem rust has afforded some protection for susceptible varieties of barley, as the stem rust on wheat attacks barley as well. By contrast, the

amount of air-borne inoculum of the leaf rusts of wheat and oats has tended to increase. This increase is attributed to the susceptibility of the new varieties, particularly those of wheat, to certain races of leaf rust that have appeared in recent years.

Cereal Smuts.—In a study of physiologic specialization in the cereal smuts, 245 collections of smut from different places in Canada were subjected to identification tests on a series of differential varieties. In addition, 100 collections of wheat bunt are being tested on winter wheat differentials at Creston, B.C. So far, the number of races of each smut identified in the collections studied was as follows: covered smut of barley, three; false loose smut of barley, one; loose smut of barley, seven; loose smut of oats, one; and loose smut of wheat, six.

Experiments on the sexuality of the cereal smuts have been continued with a view to determining the genetic relationship between species occurring on cereals, and the possible origin of new physiologic races through hybridization. *Ustilago Lorentziana*, the smut of wild barley, has been found to be heterothallic and bisexual. *U. nigra*, the false loose smut of cultivated barley, which is also heterothallic and bisexual, is sufficiently closely related to *U. Lorentziana* to form fusion cells with the latter when monosporidial cultures of opposite sex of the two species are mated on nutrient agar. Experiments made thus far, however, have failed to show that the two species are able to co-operate in establishing a diploid mycelium that will infect wild or cultivated barley and produce hybrid chlamydospores.

The embryo test for loose smut in barley was investigated at Saskatoon to determine its suitability as a routine test. Thirty samples of seed barley carrying *Ustilago nuda* were examined. Other portions of the same samples were grown in the greenhouse and in the field at two places. In each instance, the coefficient of correlation between the percentages of infection as determined by the embryo test and the growing test was over 0·97. The embryo test is preferable to growing tests because it is much quicker and it does not require greenhouse or field-plot space. In comparison with the present method of examining the current crop to determine whether or not the barley seed may be certified as free from loose smut, the embryo test has two distinct advantages: (1) the true loose smut cannot be confused with the false loose smut, and (2) due to the influence of the weather on floral infection, the percentage infection in the seed gives a more accurate estimate of the loose smut that will develop in the crop than the percentage present in the previous crop.

Foot Diseases.—Last year the discovery of *Cochliobolus sativus*, the perfect stage of *Helminthosporium sativum*, was reported. Studies at Saskatoon were continued with a view to finding a satisfactory method of obtaining perithecia in culture. Numerous monoconidial isolates of *H. sativum* were paired and grown on various media, including sterile straws, nutrient agars, surface sterilized wheat seed, and sterile wheat seedlings. Media fortified with biotin, thiamin, riboflavin, and calcium pantothenate were tried. Perithecium-like bodies developed only on Sach's nutrient agar in which wheat seeds, surface sterilized and then killed by boiling, were embedded, development being best on and around the seeds. Further work indicated that boiled barley seeds on Sach's agar were superior to wheat. Certain isolates, when appropriately paired, produced mature perithecia on this medium. From these perithecia, 25 ascospores were isolated and cultured. The cultures produced typical conidia of *Helminthosporium sativum*. Pathogenicity tests with Marquis and Regent wheats showed that all ascospore isolates, with one exception, were virulent.

Previous studies on antibiosis in relation to infection of wheat by *H. sativum* at Saskatoon have shown that the application of a culture of a suitable bacterium to wheat seed protects the young seedlings from infection by the pathogen.

This year, the influence of temperature was investigated in wheat inoculation tests with and without bacterization of the seed. The varieties Thatcher, Apex, Reward, and Marquis were studied at four temperatures. These varieties, while differing in their susceptibility to *H. sativum*, maintained their usual disease ratings relative to one another at 12°, 18°, and 24°C. At 30°C., Thatcher was more severely diseased than the other varieties, suggesting that the former is less well adapted to high temperatures. *H. sativum* was active at all temperatures, as shown by the disease ratings in seedlings from non-bacterized seed. The bacteria, likewise, were effective throughout the temperature range studied.

Seedling resistance to *H. sativum* differs widely with the wheat variety, and this resistance appears to depend in part, upon the relative abundance of the bacterial flora on the seeds. The variety Sevier, which has considerable resistance to *H. sativum*, showed a high bacterial count, whereas Reward, which has only slight resistance to *H. sativum*, carried relatively few bacteria. A closer study of the bacteria present on the seed showed that those of the *Bacillus subtilis* type were by far the commonest, and, of the cultures tested, all proved to be antibiotic to *H. sativum*. On the other hand, an unidentified species of bacteria found on the seed was strongly antibiotic to *B. subtilis* but failed to retard *H. sativum*. Some of the bacterial isolates, besides being antagonistic to *H. sativum*, inhibited or retarded germination of cereal seed.

It has been known for some time that Thatcher and Apex wheat are more resistant to root diseases than are most of the recommended varieties. Yet under field conditions and in laboratory tests these two varieties may become highly diseased, indicating that their inherent resistance to the root-rot fungi is of a low order. Similar results have been obtained by sterilization of seed and soil before tests for resistance were made. More or less complete sterilization was followed by a high degree of infection; conversely, where sterilization of the seed and soil was incomplete or omitted, the degree of infection was low. In recent years, the bacteria on seed and soil have been largely eliminated in tests in which wheat varieties were being compared for resistance to the root disease fungi. The object has been to determine the inherent resistance of varieties to these fungi in the absence of antibiotic bacteria. As a consequence, it has become abundantly clear that antibiotic bacteria on the seed and in the soil have a very important effect upon the development of root disease under field conditions. The exact role of inherent resistance in wheats to this group of diseases is still not clear, but it seems certain that without the antibiotic effects of bacteria and other soil and seed micro-organisms, the losses experienced from root diseases would be very much greater.

Arasan, a valuable fungicide in the control of black root of sugar beet, was found to be effective against common root-rot. By mixing it with soil in greenhouse tests, plants have been given a high degree of protection from root-disease fungi present in the soil and on the seed. A high concentration of Arasan, approaching 0·01 per cent by weight, is required to give adequate control, and a thorough mixing with the soil is necessary. Consequently, it is improbable that Arasan can be used as a practical control for root diseases. By the use of Arasan in small plots, it may be possible, however, to secure yield data that will show the actual losses caused by the disease.

Studies were continued on the incidence of *Helminthosporium sativum* in western crop lands and the relationship between this natural inoculum and disease onset. A survey in June from Saskatoon through Dafoe to Indian Head, then westward through Weyburn to Swift Current and back to Saskatoon through Rosetown, showed an abundance of primary lesions on wheat seedlings in some fields. It is believed that these infections came from conidia of *H. sativum* on the surface or in the top soil. When seedlings bearing lesions collected during the survey were incubated, 83 of the 119 lesions produced growths of

H. sativum. In the fall, collections of stubble were made west and northwest of Saskatoon. and these were examined for conidia. In a total of 154 wheat stubble pieces, 65 bore numerous conidia of *H. sativum.*

Experiments have shown that some soil, through the antibiotic influence of their flora, may greatly suppress infection of wheat by *H. sativum.* Tests with soil solutions and bacteria isolated from the soil, demonstrated clearly their suppressive influence on the germination of conidia of *H. sativum.* It was shown experimentally that greater infection by this fungus resulted if the soil surface were first exposed to sunshine or ultra-violet light to destroy most of the antibiotic bacterial flora.

According to data secured at the Edmonton laboratory on young plants of 64 varieties of spring wheat, those varieties which had shown greatest resistance in field tests proved to be high in catalase activity, whereas those low in resistance were also low in catalase. Catalase tests may possibly prove to be a fairly reliable and rapid technique for use in the laboratory in determining resistance of hybrid lines to root-rot. The root-rots of various cereals are also being studied by chromatographic methods and tests are being carried out to determine the amino-acids that occur naturally in the hosts. The effect of various chemicals on the growth of cereal roots growing in a vapour bath and their resistance to root-rot as affected by the various nutrients are being studied.

Of 25 varieties and hybrids of winter wheat sown in the fall of 1948, Kharkov 22, C.D. 3575, C.D. 3573, and Wasatch × Yogo were the only varieties that survived the winter.

Partial sterilization of ground barley straw with a current of gaseous formaldehyde or diethyl ether, reduced the bacterial count from 11·4 million to 132 thousand per gram, and the fungi from 2·6 million to about 5 thousand per gram.

In studies on the root-rots of cereals at Lethbridge, *Fusarium* spp. and *Helminthosporium sativum* varied in relative frequency of isolation. With spring wheat, *H. sativum* was less common than *Fusarium* spp. in the early spring, but the former occurred most frequently over the whole growing period. From winter wheat, *Fusarium* spp. were isolated more than three times as often as *H. sativum* throughout the growing season. *Fusarium* spp. predominated in oats, but *H. sativum* was most common in barley. Infection studies with representative isolates of the various fungi obtained from diseased roots of cereals were started on winter wheat in the field, and on spring wheat in the greenhouse.

In co-operative tests for varietal resistance to root-rot, 36 varieties of winter wheat were planted in the fall at Cowley, Alberta, where take-all is usually prevalent. Seedling samples examined in the late fall had a low natural infection rating and there was no apparent difference between varieties. Each variety was also inoculated in the late fall with *Helminthosporium sativum, Fusarium* spp., and a low-temperature basidiomycete. Other portions of the plots will be similarly inoculated in the early spring and in the early summer. By these means, it is hoped that information can be obtained on root-rot resistance in relation to various combinations of pathogens and environment.

Field tests of 25 varieties of spring wheat, 17 of durum wheat, and 29 of oats at Winnipeg revealed that several new hybrids and selections of each crop possessed considerable resistance to common root-rot caused by species of *Helminthosporium* amd *Fusarium.* Among the spring wheats, McMurachy's Selection again proved to be the most resistant. Other varieties showing considerable resistance were Garnet, Thatcher Selection (C.T. 920), Thatcher × Regent (C.T. 173), and Hope × Timstein (C.T. 509). Among the durum wheats, Mindum, and Ld. 303 (D.T. 204) were the most resistant. Of the oats tested, R.L. 1574 × Roxton (O.T. 128), Garry Selection (O.T. 137), and Victory showed high resistance. Several selections from the oat variety Garry showed a high degree of resistance to blight *(Helminthosporium victoriae.)*

Seed Treatments.—Co-operative tests of nine new seed disinfectants made at stations in Western Canada and the United States showed that Ceresan M and Panogen 8 were outstanding in their ability to control bunt of wheat, covered smut of barley, Helminthosporium blight of oats, and seedling blight of barley and of flax. These diseases were also controlled by Benesan 21 (diluted mercurial mixed with benzene hexachloride), but this substance reduced the germination of wheat and flax when applied in excess of the recommended rate. Anticarie, a new French disinfectant, gave satisfactory control of bunt, but it was ineffective in controlling the other diseases just mentioned.

When treated seed of wheat, oats, barley, and flax was sown in weedy plots the percentage increase in yield through treatment was found to be greater than when the treated seed was sown in weed-free plots. In general, the increase in yield was greater at low than at high rates of seeding.

The testing of different types of seed treating machines has been facilitated by comparing their performance with that of a specially designed laboratory treater. The operation of the laboratory treater can be regulated so as to distribute the disinfectant over the seed at any particular degree of uniformity desired. Variation in the load of disinfectant carried by individual seeds is determined by a new plating technique. The seeds are placed on a nutrient agar surface previously inoculated with spores of *Penicillium* and then, after incubation at room temperature for two days, the diameter of the clear zone around each seed is measured. Uniform distribution of the disinfectant is indicated by zones of approximately equal diameter.

The relative effectiveness of four new fungicidal materials as seed treatments in the control of *Helminthosporium victoriae* on Beacon oats has been tested under field conditions at Ottawa. All four materials proved to be satisfactory, with Agrosan G.N. the best and Panogen 8, Panogen 14, and R1489 x 31 slightly less effective in the order listed.

In a small test at Saskatoon where two different oils were used as carriers for Leytosan, covered smut infection in barley was reduced from 28 per cent in the untreated check to 16 per cent with one oil and 4·5 per cent with the other. At the same time Panogen 8 gave perfect control.

Studies on the hot water treatment for the control of loose smut of barley, were completed and the results are being published. The main points studied this year were the influence of the time and temperature of the pre-soak on seed injury and disease control, and the influence of broken seed-coats on seed injury. In field tests with five different samples of infected seed subjected to several variations of the treatment, all treatments gave good control. The schedule recommended consists of pre-soaking the seed for 5 hours at 70°F., dipping for 11 minutes at 126°F., cooling the seed with cold water as soon as it comes out of the hot water bath and then drying it. Ordinarily this schedule will eliminate the disease completely and reduce germination about 10 to 30 per cent.

Efficiency of Seed-Treating Machinery.—Limited tests on cereals with the Panogen seed treater, a Swedish machine that has recently been placed on the Canadian market, indicate that the machine gives satisfactory seed coverage, but further tests on a commercial basis are necessary.

Other Cereal Diseases.—Forty-five varieties of oats were tested for resistance to halo blight by subjecting them to an artificial epidemic of this disease in the field. The more susceptible varieties were severely damaged, but two of the most promising new varieties of hybrid origin, R.L. 1574 × Roxton (O.T. 128 and 130), showed satisfactory resistance.

Controlled experiments at Edmonton have shown that ergot sclerotia were badly decomposed after two months' exposure in a moist soil at 60°F., but they

were apparently not affected in a dry soil during the same period and seemed entirely intact after five months in a sterilized moist soil. Temperature, moisture and nutrition definitely influenced the germination of ergot conidia.

Diseases of Forage, Fibre, and Oil Crops

Diseases of Alfalfa.—Winter crown rot was found in over 90 per cent of the alfalfa fields examined in Alberta, but the damage was generally less severe than in 1948. The results of the alfalfa inoculation tests conducted at several points in southern Alberta were not very conclusive, for crown rot occurred throughout the fields in which the plots were located. Apparently, the degree of infection was directly related to the snow cover in the different areas. Row inoculation resulted in a higher degree of infection than did broadcast inoculation. Cutting the tops generally resulted in decreased infection. In the co-operative winter crown rot tests, infection was most severe at Winnipeg, where up to 95 per cent killing occurred. There was an unusual failure of infection at Saskatoon and Edmonton.

In continued cultural studies at Lethbridge, boron had a definite retarding effect on the growth of the winter crown rot pathogen. The growth decreased as the concentration of boron was increased in either agar or soil culture. Less consistent results were obtained with a medium prepared from the crowns of alfalfa plants that had been sprayed with boron solutions of varying concentration. In controlled temperature studies, the pathogen grew best between 10° and 15° C. Growth was slow above 20° C. and did not occur below −5°C.

A large number of hybrid lines of alfalfa, supplied by the Dominion Forage Crops Laboratory, Saskatoon, were tested for their resistance to the low-temperature basidiomycete in infested soil at Edmonton. Variable but definite disease resistance was shown in certain lines, while other lines proved to be very susceptible and were severely injured or killed.

A promising build-up of disease resistance was found in the hybrid alfalfa material tested in the bacterial wilt plots at Lethbridge in 1948-49. In the crosses between wilt-resistant and crown-rot-resistant plants, 52 out of 110 seedling lines produced a high proportion of wilt-free plants, from which 95 new selections were made. The progeny from a large number of crosses made at Saskatoon during the winter of 1947-48 appears to have a still higher degree of resistance, as no top symptoms of bacterial wilt have as yet developed. This seedling material has been left in the field for re-inoculation and further study. Among the other material tested, 12 out of 57 crown-rot-resistant selections, and 12 out of 33 rhizomatous lines were relatively free of wilt. In inoculation studies with bacterial wilt, the soak and the hypodermic methods continued to give the best results, but a more convenient spray method showed some promise.

In studies on black stem of alfalfa, it was shown in laboratory tests at Saskatoon that over 90 per cent of the seedlings may be destroyed when the seed is carrying the spores of the fungus, and the seedlings are grown under moist conditions, particularly when the temperature is high. Previously the disease was found to be seed-borne. When the course of infection in seedlings was studied, it was shown that the fungus, in most cases, passes from the seed coat to the growing point. When this organ becomes infected, growth stops and the seedling dies. The fungus is also soil-borne. Fungicides, such as Arasan that do not interfere seriously with bacterial inoculation are useful in reducing seedling infection.

Diseases of Sweet Clover.—The cause and control of a seedling blight *(Fusarium oxysporum)* of sweet clover was studied in a field plot at the Experimental Station at Melfort. This disease has been severe at that station and also on experimental plots at Saskatoon where plantings of sweet clover die off soon after

they germinate or emerge. At Melfort, sweet clover was sown untreated and treated with Arasan, at the recommended rate and at double the recommended rate of seeding. This test showed that loss in stand was due largely to rotting of the seeds at time of germination, and that Arasan reduced this rotting from about 12 to one per cent. This beneficial effect was greater in the thickly than in the more thinly sown rows.

Chemical treatment of strips of soil in field plots, into which sweet clover was seeded, failed to control seedling blight. In this test Arasan and Special Semesan were used alone and in a mixture with fertilizer.

In a survey of 72 sweet-clover fields in Essex and Kent counties during late April and early May, a root-rot disease was found in 57. Of the 49 clay or clay-loam fields examined, all disclosed the presence of some root-rot.

Isolations, microscopic examinations, and infection experiments have all indicated the primary cause of the root-rot to be *Phytophthora Cactorum*. Of the different media used to culture the organism, steamed potato slices and rolled oats were found to be the most satisfactory. Isolates of *P. Cactorum* from sweet clover appear to have an optimum temperature range considerably lower than that found for strains of the same fungus isolated from other hosts. The sweet clover strain grew at 4°C. and produced maximum growth at 16°C., with only slightly diminished growth rates at 14°C. and 18°C. Other studies indicated the causal fungus to be highly sensitive to numerous other soil organisms when they are brought into contact with it in artificial culture.

Plants from 3 weeks to 10 months old were readily infected by placing hyphal mats of *P. Cactorum* from culture flasks in direct or close contact with unwounded root tissue of sweet clover. Seedlings were also readily infected. Of the 15 varieties of sweet clover tested, all proved relatively susceptible, including D-236, which was selected in Wisconsin for its resistance to *Phytophthora* root-rot.

Studies in Wisconsin temperature tanks, on the relation of temperature to incidence of the disease confirmed the cultural tests by indicating 16°C. as optimum for disease development. However, the disease was relatively severe at temperatures ranging from 14° to 21°C.

Flax Diseases.—Pasmo was found in most of the flax fields in Manitoba in 1949, but it caused only minor damage, except in occasional fields. Over 800 varieties of flax were tested in a continuing search for pasmo-resistant material. Several of these varieties were sufficiently promising to warrant further testing. Experiments were made to determine the effect of date of seeding on disease control and yield. Flax seeded early, about mid-May, gave the highest yield. Late seeding, about the beginning of June, gave the lowest yield. Very early seeding about the beginning of May, resulted in frost injury to the young plants, some varieties being more susceptible to frost than others.

Bacterization of healthy fibre flax seed with bacteria antagonistic to *Colletotrichum linicola*, the cause of anthracnose, did not reduce the number of diseased plants in greenhouse tests in which the soil was contaminated with the pathogen. Likewise, bacterization of seed infected with the same organism did not alter the number of diseased plants when the seed was sown in clean unsterilized soil. However, when the soil was inoculated 15 days prior to sowing by atomizing it with liquid bacterial cultures, two species of bacteria reduced significantly the percentage of diseased seedlings. Such a reduction, though significant statistically, cannot be considered of practical value. When infected seed was bacterized with twelve different bacteria antagonistic *in vitro* to *C. linicola*, and the seed was sown in sterilized soil, six of the bacteria materially decreased the percentage of diseased plants, four brought no change, whereas the remaining two increased the number of blighted seedlings.

The same species of bacteria were tested under greenhouse conditions against *Fusarium oxysporum* f. *Lini*, the cause of flax wilt. None reduced the number of diseased plants when the plants were grown to maturity, but they greatly retarded the onset of wilt symptoms. The addition of green manure to the soil in a parallel experiment did not alter the activity of the antagonistic bacteria under test.

Corn Diseases.—Intensive field surveys showed that a stalk rot disease could be found in every field of corn in southwestern Ontario. Soil type had no apparent influence on disease incidence, but a considerable range of varietal susceptibility was observed. Damage from the disease was both direct, in which case severe infection resulted in small ears and shrivelled kernels, and indirect where lodging of plants was caused, interfering with harvesting operations.

Isolation studies indicated that several organisms were involved, including *Pythium arrhenomanes*, *Rhizoctonia Solani*, and *Fusarium* spp. Microscopic studies revealed the presence of *Pythium arrhenomanes* at the advancing edge of lesions, closely followed by *Fusarium* spp., *Asterocystis* sp., and meadow nematodes. Pathogenicity tests on seedlings showed that all isolates of *P. arrhenomanes* were highly pathogenic, those of *R. Solani* had a wide range of virulence, whereas certain of the *F. moniliforme* isolates were mildly pathogenic.

A disease of corn, apparently caused by a virus of the ring-spot type, was observed for the first time, on one of the corn inbreds in the Experimental Station plots at Harrow. Infected plants exhibited a considerable range of symptoms and some of the severely affected ones did not reach maturity.

Fusarium moniliforme.—A common ear-rot fungus of corn, was isolated from local seed and tested on 24 inbred lines of corn to determine whether or not it could cause a stalk-rot under field conditions at Ottawa. The inoculum consisted of a culture of the fungus grown on sterilized oat-hull medium, which was spread under untreated seed at the time of planting. Although the weather was cool, with some rain during the first week after planting—conditions favourable for the fungus—seedling emergence was not significantly reduced.

Periodic examinations of roots and stalks did not yield any evidence of invasion by the fungus, which was present in the inoculum in adequate amounts throughout the summer.

Diseases of Sunflowers.—With the increase in sunflower acreage in Manitoba from 28,000 acres in 1948 to about 60,000 in 1949, a parallel increase in rust infection occurred on commercial plantings of the Advance hybrid. As the aecial stage of the rust appears first on volunteer sunflowers, it is possible that good sanitation combined with the destruction of volunteer plants might delay the onset of rust infection. The most promising means of preventing rust damage, however, appears to lie in the development of resistant varieties. Experiments, in co-operation with the plant breeders, have already been started with this object in view.

Defoliation experiments were made on sunflowers to determine the effect on yield of varying amounts of leaf injury, such as might be caused by rust. It was found that complete defoliation when the plants were in full bloom reduced the yield of seed by 90 per cent.

Turf Diseases.—The control of snow mould, a low-temperature disease of fine turf grasses, is under investigation co-operatively with the Division of Forage Plants. The disease may be caused by one or more fungi acting alone or in combination, but to date only a species of *Typhula* has been associated with snow mould in the Ottawa area. Pathogenicity tests indicate that this fungus is parasitic on several strains of bent grass (*Argrostis* spp.).

Late Blight.—In 1949, a potato fungicide committee was set up to co-ordinate the work of testing fungicides for the control of late blight being done by laboratories in the leading potato growing provinces. Under this scheme, new fungicides are screened at Charlottetown, and those materials that show promise are then tested in other provinces. This plan permits the rapid assessment of the merits of the more promising fungicides under a variety of meteorological and disease conditions.

At Charlottetown, in the co-operative test, the fungicides were compared under severe epidemic conditions as September proved to be a very wet month. Under these conditions, the copper fungicides used were superior to the organic fungicides. Of the four copper fungicides, bordeaux mixture gave the greatest protection, Basi-Cop and C.O.C.S. were approximately equal in value but less efficient than bordeaux, whereas Perenox was the least effective. The two organic fungicides, Dithane D-14 and Parzate, failed to control late blight satisfactorily, the latter fungicide being of little value. Plots treated with bordeaux mixture gave the highest yield and suffered least from tuber rot, and, despite heavy late-season defoliation by late blight, plots treated with Parzate, an organic material, were second highest in yield.

The co-operative test was also carried out at Fredericton and Kentville. At Fredericton, no late blight appeared on the vines owing to the hot, dry season. Parzate gave a significantly higher yield than the other fungicides, and Perenox, Basi-Cop, Dithane D-14 and C.O.C.S. were superior to bordeaux mixture and the untreated check. At Kentville, the plots started to die down early in August, although later there was some recovery. Positional differences in the field were large and differences due to treatment were not found.

Five relatively new fungicides were screened at Charlottetown, with bordeaux mixture included for comparison. Crag 658, bordeaux mixture, and Cop-O-Zink gave the best control of late blight on the foliage, in each case the percentage of defoliation being significantly lower than in the plots sprayed with the organic materials SR-406, Phygon XL, and Good-rite Z.A.C. Under the conditions of the experiment, the organic fungicides offered little protection, and towards the end of the test the plots treated with Good-rite Z.A.C. were almost as completely defoliated as the check plots. Phygon XL at the rate of 2 lb. per 80 gallons gave excellent control of late blight in 1948, but the maturity of the plants was strikingly retarded, and the yield was low. In 1949, with the concentration reduced to 1 lb. per 80 gallons, Phygon XL failed to control blight and yields from the treated plots were even lower than those of the untreated. Not only was good control of late blight obtained on the foliage with Cop-O-Zink, Crag 658, and bordeaux mixture, but the plots sprayed with these fungicides gave marketable yields significantly higher than the check plots.

In a preliminary experiment at Ottawa to determine the feasibility of applying concentrated fungicides for the control of potato diseases, particularly late blight, Green Mountain potatoes were sprayed with copper fungicides at 4 concentrations at 65 lb. pressure with or without an air blast to disperse them. The materials used were bordeaux mixture, burgundy mixture, and the fixed coppers, Copper A and Basi-cop. The rate of application in all cases was equivalent to bordeaux mixture 10-2½-100; burgundy mixture, 10-10-100, and fixed coppers, 4 lb. per 100 gal., all at the rate of 100 gal. per acre. The actual volume of spray solution applied was for bordeaux and burgundy mixture 100, 86, 65, and 48, and for fixed coppers, 86, 48, 21, and 14 gallons per acre. The bordeaux and burgundy mixtures, could not be applied in more concentrated form because, when the volume of water was reduced below 48 gallons, the liquid was too viscous to pass through the sprayer. All the plots, including the check rows, were sprayed with DDT to control insects. The weather was hot and

dry till the end of August, and no late blight appeared on the foliage, but a considerable amount of early blight developed. The use of the air blast to disperse the fungicides, in general, appreciably reduced the amount of early blight on the foliage, and of late blight on the tubers. The percentage of late blight tuber infection with the different volumes of spray solution varied greatly, but the smaller volumes appeared to be nearly as effective as the larger ones.

Conidia of *Phytophthora infestans* were caught on slides exposed in different localities in eastern Quebec, but not until after late blight had become established in the field. It has been impossible to forecast an outbreak of the disease in a district by means of this method. Late-planted potatoes showed late-blight infection from three to seven days later than potatoes planted from two to six weeks earlier. In one locality the difference in infection between early and late plantings was quite evident, even at digging time, but in other places, where traces or only light infections of the disease were observed, no difference was noticeable between the different plantings toward the end of the season.

Virus Diseases of Potato.—The use of radio-isotopes has opened up a new and fertile field of study in virus research. Further studies conducted in co-operation with the Physics Department of the University of New Brunswick have shown that radiophosphorus, P^{32}, is a valuable tracer for studying the course of phosphorus in potato plants. The use of P^{32} has shown that the uptake rate of phosphorus is more rapid in potatoes affected with certain viruses than in stocks known to be free from these viruses. This result suggests the possibility of utilizing P^{32} as a tracer in a practical method of estimating the virus content of seed potatoes. It has also been confirmed that the aphid *Myzus persicae*, which serves as a vector of important virus diseases, is capable of ingesting detectable amounts of P^{32}, and by this means the dispersion of an aphid population may be traced from a given source.

Researches conducted in co-operation with the Biology Department of the University of New Brunswick have revealed that the fluorescence (in ultra-violet light) associated with net necrosis in potatoes is caused by a compound designated as scopoletin. The metabolism of this compound by healthy and leaf-roll-infected tubers was investigated and the nature of the enzyme system and metabolic products partially characterized. It was found that tubers free from the leaf-roll virus metabolize scopoletin more rapidly than do leaf-roll-infected potatoes.

A total of 150 grafts of scions infected with the leaf-roll virus were made at Edmonton on healthy plants of Carter's Early Favourite, Netted Gem, and Canus. These grafts were made at 10-day intervals, beginning when the plants were about from two to four inches high. Results indicated that phloem necrosis of the tuber was correlated with infections of the leaf-roll virus induced during the early part of August rather than with those induced during July. All varieties tested were susceptible to the virus but not to phloem necrosis.

Further investigation of the bunch top (purple top) disease of potatoes at Fredericton has shown that a number of the commercial varieties of potatoes are susceptible to the disease. Bunch top also causes misses in the field by preventing the eyes from sprouting, and gives rise to weak plants by interfering with the metabolism of tubers completely invaded by the virus. The disease also produces symptoms that resemble the current-season effects of leaf roll and gives rise to necrotic symptoms in the tuber resembling the early stages of blackleg and net necrosis. The virus was found in petunia, matrimony vine, snapdragon, milkweed, and tomato under field conditions. Proof has also been obtained that at least two types of bunch top occur in potatoes in Eastern Canada. The viruses associated with bunch top appear to be different to the type strain of the aster yellows virus, *Callistephus* virus 1.

In the "aster yellows virus garden" planted at Ottawa to investigate the hypothesis that bunch top (purple top) of potatoes caused by the aster yellows virus, Sebago potatoes were interplanted in randomized rows with China aster, carrot, celery, tartarian buckwheat, and zinnia, all known to be susceptible to aster yellows. At harvest time, 8 per cent of the Sebago plants showed bunch top symptoms, whereas 32 per cent of the China asters, 1 per cent of the carrots, 2 per cent of the zinnias, and 0·3 per cent of the celery plants had yellows. None of the buckwheat plants showed any yellows symptoms.

In a study of witches' broom of potato at Vancouver the virus was successfully transmitted by grafting the White Rose variety to U.S.D.A. Seedling 41956 with the development of typical symptoms. Seedling 41956 is believed to be immune to the latent or X-virus of potatoes. As the X-virus is present in all White Rose stocks, there was the possibility that witches' broom might be the result of the combined infection by the two viruses. However, as the disease that developed in Seedling 41956 followed the same symptom pattern as in White Rose, it is evident that the X-virus and the witches' broom virus operate independently of each other.

When a diseased scion is grafted to a young Seedling 41956, first symptoms appear in 6 to 8 weeks. These are a slight rolling of leaflets, a shortening of the internodes of new growth, and some axial growth of stems. The symptoms become pronounced by the fourteenth week, when, in addition, new growth appears from normally dormant buds below ground level. The main plant matures by the twentieth week at which time aerial tubers at nodes are abundant. After the death of the mature plant, growth from newly formed tubers will continue, and this growth exhibits symptoms of the typical witches' broom stage. Leaves are smooth and somewhat chlorotic, simple rather than compound, and distinctly reduced in size. Growth occurs from nearly all buds, producing an extremely fasciculated haulm. Stems are numerous, slender, cylindrical rather than angular, and have bulbous nodes. Tubers produced after this stage is reached are very small, but their number is greatly increased. They are often produced in bead-like fashion on the stolons. Such tubers are so reduced in vigour that they will rarely produce plants capable of setting tubers.

Resistance of Potato Seedlings.—Further progress was made in determining the late-blight, ring-rot and common-scab resistance of potato seedlings newly developed under the co-operative breeding project with the Experimental Station at Fredericton. Out of 240 first-year seedlings tested, 234 showed marked resistance to late blight infection. From the multiplication lots, 165 seedlings showed a high degree of resistance to foliage infection coupled with desirable tuber characters. Twenty-four blight-resistant seedlings possessing good horticultural characters were tested for ring-rot resistance; two seedlings showed no evidence of infection at digging time. Resistance to common scab infection was determined in 5,288 seedlings under field conditions; 186 of them showed promise of satisfactory resistance to common scab.

The testing of potato varieties for resistance to Verticillium wilt, Fusarium storage rot, and blackleg was begun at the Charlottetown laboratory in 1949. Of the named varieties, Houma showed high resistance to Verticillium wilt when clean seed was planted in infested soil. A 4 per cent infection was recorded in Houma, whereas infection in the varieties Green Mountain, Katahdin, Irish Cobbler and Sebago varied from 27 to 33 per cent.

Common scab of Potato.—The Provincial-Dominion Committee has continued its investigations on common scab. The units co-operating on this include several departments of the Ontario Agricultural College, the Botany Department of the University of Western Ontario, and units of the Canada Department of Agriculture. In 1949, the following results were obtained from the field plots:—

(1) The lowest scab readings were obtained from tubers grown in soils having a pH of 5·5 or lower. The highest scab readings were observed in soils approaching neutrality (pH 6·0-7·0). Where the soil reaction was alkaline, scab readings were low, but not so low as where the soil was acid. In this respect the results of 1949 are in close agreement with those of 1948.

(2) Addition of sulphur, 1,000 lb. per acre, was most effective in lowering soil pH. Also, scab incidence was low in the sulphur plots. Soybeans lowered soil pH in some plots and raised it in others, making the effect of this crop obscure.

(3) Lime at 1,000 lb. per acre raised the soil pH appreciably.

(4) In general, there was a tendency in all plots, except those treated with sulphur, for the soil pH to increase slightly during the growing season.

(5) In 1949, high scab readings correlated with increased organic matter in the soil, whereas in 1948 low organic matter correlated with high scab incidence. This contradiction indicates that observations must be continued over a number of years before the effect of organic matter on scab development may be understood.

Each co-operating unit is investigating some particular phase or phases of the scab problem. The Bacteriology Department, O.A.C., and the St. Catharines Laboratory have been seeking a short-cut method for the identification of parasitic strains of the common scab organism. It has been reported in the literature that only parasitic strains produce brown rings in milk culture. However, research at St. Catharines has clearly indicated that both forms that do and those that do not produce brown rings are parasitic. The Bacteriology Department is now investigating the serological method as a possible short cut for the identification of parasitic strains.

The Botany Department, O.A.C., is making an anatomical study of the mode and loci of infection on susceptible and resistant varieties. Infection appears to be confined to the scab lesion and is apparently quite superficial. Cork is laid down in a very uneven pattern, suggesting that it may not be an efficient barrier to all infections. The St. Catharines Laboratory has demonstrated that tubers may become infected anytime during the season, so long as the tubers are growing. Infection is not confined to the period when the tuber-initial is being formed. Two types of lesions have been recognized. On inoculation, cultures isolated from each type of lesion produce only their own type of lesion. This finding suggests that the type of lesion may be correlated with definite strains of the fungus.

Experiments at St. Catharines with Wisconsin soil temperature tanks have indicated that low soil moisture and high temperature favour scab. In the same experiments, soybeans as a cover crop reduced scab 50 per cent, even under conditions most favourable for scab development.

The possibility of using the phenomenon of antagonism as a means of control is being investigated. Already six fungi have been found that have proved strongly antagonistic to the organism *(Streptomyces scabies)*. These are *Aspergillus fumigatus, Myrothecium roridum, Myxosporella* sp. *Trichoderma album, Alternaria tenuis* and *Gliocladium roseum.*

Thirty seedlings and several varieties have been tested for their resistance to scab in six counties in Ontario; several seedlings and the varieties Menominee, Ontario, and Seneca have shown a high degree of resistance.

Bacterial Ring Rot.—Studies on the nutrition of *Corynebacterium sepedonicum*, the potato ring rot organism, to permit its isolation in the presence of contaminants were made both in the Division at Ottawa and at Macdonald College. In the latter institution, a Warburgh respiration apparatus was available for these studies and greatly expedited the work. The roles of vitamins, amino acids, and trace elements in the nutrition of this organism were investigated, and,

with this information, a new medium was devised on which the organism could be isolated in from 3 to 4 days, as compared with 8 days on buffered potato dextrose agar.

In 1949, tubers from 17 lines of the Commonwealth Potato Collection that in previous tests had failed to show any bacterial ring rot infection, were inoculated with the causal organism and planted in the greenhouse at Ottawa. Of these, only seven lines produced tubers and two of these were found to be infected upon microscopic examination of smears from the tubers at harvest time. Since 1945, 135 lines have been tested, and 15 have shown no infection.

In 1949, further tests were made to determine the resistance of the variety Teton to bacterial ring rot. Three lots of Teton tubers were planted in the field, one lot without treatment, one lot needle-inoculated with a suspension of *Corynebacterium sepedonicum* from cultures, and one lot inoculated by cutting into the sets with a knife contaminated by cutting through a diseased Green Mountain tuber. For comparison, healthy Green Mountain tubers needle-inoculated with the same pure cultures were also planted. As in previous tests, no symptom of ring rot was observed on the Teton plants. At harvest time, the tubers were examined macroscopically by cutting them at the stem end. Those suspected of being infected with bacterial ring rot were examined microscopically. The percentage of plants showing macroscopic symptoms and those found infected only upon microscopic examination were as follows: needle-inoculated Teton, 10·6 and 3·9; knife-inoculated Teton, 18·7 and 5·8; Teton checks, 0; Green Mountain needle-inoculated, 100.

To determine the effect of the Teton variety on the pathogenicity of *Corynebacterium sepedonicum*, the diseased Teton tubers produced in 1947 as the result of inoculation, were planted in 1948, and the diseased tubers from the 1948 crop stored during the winter. In the spring of 1949, 10 of the tubers which showed the presence of the organism upon microcsopic examination were selected. Each tuber was then cut with a disinfected knife into 4 sets, after which a healthy Green Mountain tuber was also cut into 4 sets. Some of the progeny of five of the Teton tubers had ring rot, and the corresponding Green Mountain plants were also infected. Two of the Teton tubers produced healthy tubers, but the progeny of the corresponding Green Mountain tubers were diseased. The remaining three Teton tubers produced healthy tubers and the disease was not transmitted to the Green Mountain tubers.

The ring rot organism incorporated into sterilized and unsterilized soil and exposed to freezing temperatures for 15 days was isolated at Ste. Anne de la Pocatiere laboratory from the sterilized soil only. *Corynebacterium sepedonicum* can, therefore, withstand low temperatures but not the antagonism of soil-inhabiting micro-organisms. The pathogen may overwinter on sacks, boxes, and baskets under the climatic conditions prevailing in Eastern Canada, and may cause infection when potato sets are placed in these containers at planting time. A heavier infection resulted from containers that were kept indoors during winter than from those that were exposed to outdoor temperatures. Farm implements that have come in contact with a potato crop affected with ring rot may transmit, to a slight extent, the disease to healthy seed the following spring, for sound potato sets rubbed against contaminated parts of such implements, either in the fall or spring, developed traces of the disease.

Among the numerous micro-organisms isolated and tested for their antagonistic behaviour toward *C. sepedonicum*, four different bacteria inhibited the growth of the ring rot organism in potato plants when the freshly-cut surface of potato sets was inoculated simultaneously with the test organism and the pathogen.

Potato Rot Nematode.—Studies conducted over a 4-year period have shown that the potato rot nematode can survive three years in soil under summerfallow,

with, however, some apparent reduction in the infestation. Continuous cropping to potatoes also revealed decreasing infestation with successive cropping.

Highly significant increases in soil infestation by the potato rot nematode have been secured following field fumigation with chloropicrin gas. Increased infection was first observed in 1948 in plots treated with this chemical in 1946. Similar results were obtained in 1949 following fumigation in 1948. It is considered probable that chloropicrin disturbed the normal biologic balance of the soil by being more toxic to the parasites or predators of the potato rot nematode than to the nematode itself.

Herbicides have proved entirely ineffective as an indirect means of eliminating the potato rot nematode from the soil. Hand-fallowed and unfallowed controls were maintained during the first half of this test and a heavy growth of clover occurred in the absence of cultivation. Subsequent planting to potatoes revealed higher infestation where the land was not fallowed. Results indicate that clover contributed to the maintenance or increase of the nematode population.

The development of nematode tuber decay has been studied over a temperature range of 35°F. to 71°F. After four months storage, 6 per cent of the tubers held at 35°F. show macroscopic symptoms, whereas 35 per cent show visible symptoms at 71°F. High temperatures are required for full symptom development in tubers previously infected in the field.

Potato Vine Killers.—Further tests with herbicides were conducted at Ottawa in 1949 to determine their suitability for killing potato tops prematurely as a means of preventing late blight tuber rot, but without causing undue vascular discoloration. Handy killer (sodium arsenite) and fuel oil, Sinox General (dinitro ortho secondary amyl phenol) and fuel oil, and Dowspray 66 Improved (dinitro ortho secondary butyl phenol, Triton B 1956, and mineral oil), and aluminium sulphate were applied to individual plots of Green Mountain potatoes on September 9, 15, and 24. The weather was cool and moist throughout this period. Handy Killer killed the tops in 9, 8, and 9 days; Sinox General in 7, 6, and 5 days; and Dowspray 66 Improved 6, 7, and 7 days, respectively, following application. The average ratings for internal discoloration in the tubers, determined by examining 200 tubers from each plot at harvest time and a similar number after 3 months' storage, were as follows: Check, 0·5 and 0·8; Handy Killer, 34·5 and 23·3; Sinox General, 50·2 and 22·8; and Dowspray 66 Improved, 54·8 and 27·3. In general, the incidence of internal discoloration varied directly with the rate of killing of the plants.

The killing of the potato vines prior to harvest continues to be a good practice in the production of potatoes in Prince Edward Island. Because a severe late-blight epidemic was forecast in early September, the growers were urged to destroy the vines promptly. Surveys have shown that growers who killed the vines not later than the middle of September harvested healthy crops, whereas many growers who did not kill the tops or who postponed treatment until late September after heavy rains fell suffered heavy losses, in many cases the loss being far in excess of the additional yield gained by the longer growing period.

Sodium arsenite products kill the vines slowly, but when an oil, such as waste crankcase oil, or common salt is added, the killing rate is increased. Dowspray 66 Improved and Sinox General are much quicker than the arsenicals in killing the plants, but these products show a tendency to induce discoloration in the stem end of the tubers. With all top killers the vines should be dry when the applications are made. This precaution is particularly important when sodium arsenite-oil sprays are used.

Other Diseases.—Wilt *(Verticillium alvo-atrum)* is a frequent cause of rejection of seed potato fields in Prince Edward Island. The results of work done on the disease this year confirm previous findings, that excellent control is given

by seed treatment with Semesan Bel. Further, it was shown that the organism overwinters in infested soil, and thus such soil constitutes a further source of infection.

Several cases of severe loss from Fusarium storage rot were again recorded. Comprehensive tests were conducted to determine if field exposure or pre-storage curing would lessen the disease incidence. These measures, however, were found to be ineffective. Treatment with "Fusarex" dust, recommended in the British industry for a similar disease, was likewise ineffective under the conditions of these tests. Careful handling of the crop and constant cold storage were again found to give the least incidence of rot.

Evidence was obtained at Saanichton that the dusting of potato tuber sets with Fermate protected them against premature rotting by *Fusarium oxysporum* thus insuring a better stand or greater freedom from misses.

Studies were continued at Edmonton on the persistence of *Rhizoctonia Solani* in the soil, as influenced by host and non-host crops, and also on the pathogenicity of isolates as secured from sclerotia, disease lesions, and from basidiospores.

Diseases of Vegetables and Field Crops

Seedling Blight of Asparagus.—A new seedling blight of asparagus, first observed in Ontario in 1945 and again in 1949, was found to be caused by *Fusarium oxysporum.* Affected seedlings are stunted, yellowed, or wilted. Wilting is associated with a complete collapse of sections of the primary root. Although primarily a seedling disease, there is some evidence that the pathogen causes the development of weak shoots that are found in mature plants.

Onion Diseases.—A neckrot of Spanish onion seedlings caused plant losses up to 50 per cent in certain fields in southwestern Ontario. Isolations and infection experiments proved the causal organism to be *Botrytis Allii.* Soil temperature was found at Harrow to exert a profound effect on disease development, with disease incidence in constant temperature tank experiments ranging from 74·1 per cent at 15°C. to 11·6 per cent at 25°C.

A disease known as 'onion failure' was also investigated. This disease has occurred in several of the Ontario onion marshes for at least the past decade. The symptoms consist of yellowing of the leaf tips, followed by various degrees of stunting. Roots of affected plants are pinkish, flaccid, and necrotic. Isolations, microscopic examinations, and infection studies indicate that a complex of organisms is involved.

Soybean Diseases.—Experimental work on soybeans was largely confined to brown stem rot, a disease currently menacing the crop in Illinois and other important soybean-producing States. The experiments were designed to determine varietal resistance to, and the effect of crop sequence on the disease. Nine of the commonly-grown varieties, namely, Hawkeye, Lincoln, Earlyana, Richland, Harly, Harman, Capital, A. K. Harrow, and Adams, were planted in a randomized, 5-replicate design in a plot half of which had been planted to soybeans last year, the other half to white field beans. Periodically during the latter part of the growing season, stems of plants were cut open and examined for the presence of the disease. No variety was found to show resistance to the disease, but there did seem to be a definite correlation between incidence of the disease and stage of maturity of the plant. Quite definitely, its incidence on all varieties was higher in the plots where soybeans followed soybeans than in those where soybeans followed white beans. There is also strong circumstantial evidence that high humidity favours disease incidence.

Diseases of Sugar Beet.—Experiments on the prevention of black root of sugar beet seedlings were continued both in the greenhouse and field in south-western Ontario. The effectiveness of Ceresan M, borax, and D-419 (a proprietary formulation containing 50 per cent tetramethyl thiuram disulphide) have been compared with that of Arasan in controlling black root. Results obtained with Ceresan M and with borax at rates of 2 and 5 lb. per acre, respectively, have been so favourable as to warrant field trials with these chemicals. D-419 has been found not only to equal Arasan but, in certain respects, to be preferable to it.

In field tests in which different formulations of t.m.t.d. mixed with standard commercial fertilizer were added to a field soil with a recent, definite, black root history, unthinned stands of seedlings receiving the t.m.t.d.-fertilizer mixture exceeded those receiving the fertilizer alone by from 34·7 to 61·3 per cent. Furthermore, counts made subsequent to blocking and thinning operations showed gains for the treated rows over the untreated of from 8 to 35 per cent. Differences in early stands of seedlings have been reflected in increased yields of mature beets, ranging from 0·36 to 3·43 tons per acre, depending on the rate of application and the particular formulation of the chemical.

Sugar beets proved remarkably free of foliage and stem diseases in survey studies made this year by the Lethbridge laboratory. Root diseases, however, were found at all stages of plant growth. Black root in seedlings occurred in 93 per cent, and was estimated as moderate to severe in 24 per cent of the fields examined in May and June. It was equally prevalent in all of the sugar beet areas. The highest mortality occurred during the early damping-off stage of the disease. Later in the season, a root rot, apparently caused by the same fungi as black root, occurred mainly in patches in the lower areas of the fields. It was found in 24, and was estimated as moderate to severe in 12 of the 38 fields examined in September. As a further check, over 5,000 beets were examined in the storage piles during their removal in November. A total of 5·4 per cent of these beets were infected and 1·9 per cent were severely rotted. The degree of rotting was consistently higher in some piles than in others. A study of hook wounds indicated that decay often progressed slightly in individual beets during storage, but there was no evidence of a spread of infection from one beet to another. The occasional heated spot in the piles usually originated in a breakdown of frozen or immature beets. Several different fungi were isolated from the diseased seedlings and rotted beets and attempts are being made to determine their relative importance. *Phoma Betae,* apparently introduced by the seed, occurred most commonly. Isolates of this fungus from seed and from diseased seedlings caused severe rotting of mature beets in inoculation tests in the field and laboratory.

Tobacco Diseases.—In experiments to control brown root-rot of tobacco in the field, 6 different soil fumigants were applied to infested field soil, and their relative effects on burley tobacco were compared. The chemicals were applied in the row at different rates with a hand injector 10 days before planting. Wide differences were obtained in root injury and green weight yields between treated and untreated plots of the susceptible variety Harrow Velvet. The soil fumigants apparently acted as nematocides in the present experiments. The variety Green Briar is evidently much more tolerant to nematode populations in brown root-rot soil than most other varieties grown in Ontario. Of the various fumigants used, Dow N, Chloropicrin, and Dow W40 resulted in greatly increased growth of Harrow Velvet and thus appear to offer particular promise for the control of brown root-rot of tobacco.

An intensive study of *Thielaviopsis basicola,* the causal organism of black root-rot of tobacco, revealed the normal occurrence of 2 distinct cultural types in Ontario soils. These cultural types have been recognized and described as light and dark with reference to their colour and appearance on potato dextrose

agar. The mutation light to dark and *vice versa* in the soil is of an oscillatory nature, but the factors causing and directing the mutation are not known. Circumstantial evidence suggests the hypothesis that the mutation is associated with the host-parasite relationship. The light to dark mutation has never been observed with certainty to have taken place under conditions of artificial culture. However, this mutation occurs in some instances with passage through the host. The dark to light mutation occurs readily both in culture and in the host. Only light-type cultures have been isolated from host material obtained from Virginia. and this type is stable both in culture and in the soil with respect to the light-dark mutation. Both light and dark types proved to be relatively stable both in culture and in the soil under the conditions of the experiments. Numerous variants or mutants of the light and dark types arising under conditions of artificial culture have been recognized and described.

Tomato Diseases.—Quadruplicate plots of tomatoes at Kentville received six fungicide treatments for comparison of disease control. Four applications were made at 10-day intervals. Bordeaux mixture was used at two strengths, and Phygon and Tribasic copper sulphate in straight schedules. Two applications of Zerlate followed by two of bordeaux comprised the fifth treatment, and Basicop dust the sixth. Excellent commercial control was obtained. The crop was left in the field late, owing to the absence of frost, and all plots developed some late blight. The untreated plots were completely destroyed. The season favoured severe blossom-end rot and cracking of the ripening fruit. The bordeaux schedules increased the roughness of the fruit.

In the search for a resistant parent with which to breed tomato varieties resistant to late blight, plants from one of two seed lots received by the Dominion Arboretum from the Philippine Islands, have so far remained free from late blight after several artificial inoculations in the greenhouse.

Turnip Diseases.—Eleven lots of Ditmars turnip stecklings were brought from the Digby area during the fall of 1948, and stored at Kentville. These lots were planted in the spring and whenever possible beside turnips obtained from the farmers' own storage. Three farmers lost their stecklings in storage, and three others suffered severe losses, but planted what was left. The common rot in storage was found to be caused by *Rhizoctonia Solani*. When sound stecklings were planted, there was apparently little additional loss from rot.

Testing for Varietal Resistance to Disease in Beans and Peas.—By inoculation under field conditions, 112 bean varieties and selections were tested for resistance to common and halo blight. Although 38 selections remained free of halo blight, only 1 remained free of common blight. The resistance of 64 bean selections to anthracnose was determined under field conditions, with 27 selections remaining free of infection.

Tests to determine the resistance of pea varieties to Ascochyta blight included 85 varieties under field conditions and 16 selections in the greenhouse. A number of varieties appeared to be resistant, but an investigation to determine whether or not physiologic strains of Ascochyta were involved is being undertaken.

Chemicals for Control of Diseases in the Soil.—In assessing the value of Arasan for use in seed and soil treatments to control damping-off of pepper and spinach seedlings caused by either *Pythium ultimum* or *Rhizoctonia Solani*, it was found that this chemical was highly effective against the former organism but not so effective against the latter. In later experiments in which the comparative effectiveness of various chemicals in controlling *Rhizoctonia Solani* on muskmelon seedlings was tested, Tersan and Arasan proved quite effective in controlling both pre- and post-emergence damping-off caused by this fungus.

Apple Scab.—Work was begun at Ottawa on a co-operative project with the Division of Horticulture, Experimental Farms Service, in the breeding of apple varieties resistant to scab. The causal fungus was isolated from scabby fruits from five widely separated points across Canada, and pure cultures were received from Kentville, Nova Scotia, and St. Jean, Quebec. The fungus was multiplied on 1 per cent malt extract in 250 ml. Erlenmeyer flasks on which it sporulated abundantly. Suspensions of spores from the flasks were atomized onto seedlings from crosses and from open-pollinated blossoms of both susceptible and resistant parents. The technique proved effective in testing for scab resistance. The ratio of resistant to susceptible seedlings from seed produced by open-pollinated blossoms of the Geneva ornamental crabapple was approximately one to one.

In a test, for disease resistance, of *Malus* species conducted in co-operation with the Indiana Experiment Station, all species under trial at Kentville have remained free of scab, without the application of fungicides.

Comparisons of fungicides were made at Kentville in various orchard blocks, but the differences in scab control, as observed on the harvested fruit, were not significant, except in two plots. Scab control in plots sprayed with Fermate and with Mercurated lead arsenate was inferior to the control obtained in those sprayed with Flotation sulphur paste, Magnetic 70 sulphur paste, Crag 341C, Phygon XL, Tag HL311, Venturicide, and Puratized Apple Spray (B). A preliminary test of other fungicides gave no results, as no scab appeared on the control trees.

Weather conditions in western Quebec were unusually favourable for the control of apple scab throughout the season. Primary infection was the result of a heavy ascospore discharge during a rainy period on May 22-23. This infection was localized on the fourth, fifth, and sixth leaves of the branch. Warm dry weather in June and July prevented further development on the leaves and almost no scab developed on the fruit.

Eight applications of each of four fungicides, Magnetic 70, Mulsoid, Fermate and Phygon XL, were made for the control of scab as follows: Green tip, pre-pink, pink bud, calyx, and four cover sprays. Owing to noticeable injury caused by Phygon, it was replaced by Magnetic 70 in the last two sprays. Large counts (3000 leaves from each treatment) showed that Mulsoid gave the poorest control, Fermate slightly better, Magnetic 70 the second best, and Phygon almost clean foliage. The percentage of scabby fruit was even lower; here trees sprayed with Fermate had the cleanest fruit. This result corroborates other experiments, indicating that Fermate is an excellent protectant against scab in the cover sprays. Although some russeting was noticed on small fruits of Phygon-treated trees on June 11, final counts indicated that the amount of russeting was of a very low order.

On account of drought conditions during the summer, scab infection was extremely light in the Niagara Peninsula. As a consequence, trials with fungicides for the control of scab gave no conclusive results.

Nineteen treatments, including four new products, were tested. The fungicide, which was unusually effective in the severe scab year of 1948, was less so in 1949, probably because its function this season was as a protectant rather than as an eradicant. The new products tested were CR305, SR406, Aaventa, and Arathane. Results with Arathane indicated that it would prove unsatisfactory under severe scab conditions.

The lack of fruit buds on trees sprayed with Phygon in 1948, was an outstanding feature of the experimental orchard. The yield from these trees averaged less than $\frac{1}{2}$ bushel per tree compared with 5 to 7 bushels harvested from trees sprayed with other materials, although some of the latter trees suffered severe scab infection in 1948. The tendency of Phygon to cause severe injury

to the trees has been a decided weakness of this otherwise excellent fungicide. The inclusion of magnesium sulphate as a corrective and the use of Phygon at a lower concentration and in combination with other fungicides, as was done in the 1949 trials, appeared to prevent observable injury.

Crag 341C caused considerable fruit russet in 1948, but this type of injury did not recur in 1949. It appears to be less efficient as an eradicant than other organic materials. As eradicants, the mercurials and Phygon were promising even when applied four days after an infection period, CR305 and lime sulphur were less effective under similar conditions.

Experiments in the control of apple scab were conducted by the Summerland laboratory in co-operation with the British Columbia Department of Agriculture. In the Salmon Arm district, the fungicides lime sulphur, Puratized agricultural spray, Tag, and CR305 in the pink and calyx sprays with ferbam and wettable sulphur in one cover spray, gave good commercial control with over 90 per cent marketable fruit. A three-spray schedule with two kinds of concentrate machines gave 90·6 and 90·2 per cent marketable fruit in comparison with 99·6 per cent when a conventional gun machine was used.

In the Creston district, in the second year of a 5-year comparison, both lime sulphur and a ferbam-mulsoid sulphur combination in a five-spray program gave all marketable fruit, but the yield was 85 per cent higher in the ferbam-mulsoid sulphur plot. The fungicides Phygon XL. HL331, and 341C gave satisfactory but slightly poorer control than standard fungicides. HL331 caused severe defoliation on Delicious. Two types of concentrate sprayer gave control comparable to that by conventional machines and foliage injury was less.

Effect of Saprophytic Fungi on the Development of Venturia inaequalis.—Research, mostly carried out at Macdonald College, on the effect of different saprophytes inhabiting dead apple leaves on the apple scab fungus reveals that they may act in different ways. Of 63 saprophytes isolated from dead leaves, seven completely inhibited the growth of *Venturia inaequalis* in culture, four others were nearly as effective, and the remaining 52 caused only partial or no inhibition. Eight organisms readily decomposed cellulose and 12 others were somewhat active; six readily dissolved the middle lamella of the leaf cells, whereas eight others produced a small amount of pectinase. Thus these latter fungi may decompose dead apple leaves readily through their cellulase and pectinase activity, thereby preventing the scab fungus from completing its development. Studies are being continued in co-operation with Prof. J. G. Coulson of Macdonald College.

Zinc Deficiency.—In co-operation with the Division of Chemistry at Summerland, apple trees that showed a little-leaf and rosette condition were sprayed during the dormant period with a solution of zinc sulphate (20 lb. in 100 gal.). A marked recovery of the treated trees was noted. It is believed that this is the first record, in Canada, of the correction of a tree-fruit disorder with zinc.

Apple Mosaic.—The mosaic disease of apple has steadily increased in a commercial orchard under observation during the past ten years. In 1939, there were 13 affected trees in a block of 58 trees of the Golden Russet variety. In 1949, 25 trees were showing mosaic in the same block. The spread of the disease appears to be associated with pruning operations.

Pear Scab.—A study of the fungus causing pear scab revealed that ascospores matured more than two weeks later than the spores of the fungus causing apple scab. The fungicides bordeaux mixture, Tag HL311, Crag 341C, and Phygon XL were found to be more toxic to the fungus than sulphur or Fermate.

Virus Diseases of Stone fruits.—In the Okanagan district, small bitter cherry, formerly reported as being non-transmissable, did appear in 1949 in trees grafted in 1941. It must therefore be considered as a slowly transmissable virus disease. Its natural occurrence in orchards is increasing. In the annual survey for little cherry with the Provincial Department no affected trees were found.

In the Kootenay district, three symptomless Lambert trees found growing in orchards affected with little cherry are being tested for immunity. Budding to healthy trees has demonstrated the virus as present in one of the three symptomless trees. Buds from all three trees, when placed on diseased Lambert, have produced fruit with typical little-cherry symptoms. Complete symptom masking has been obtained in fruit on individual limbs by severe reduction of incident light.

A survey of 23 sweet cherry plantings in the Niagara Peninsula showed that tatter leaf was present in 18 orchards and was suspected in 4 others. Crinkle was another disorder found in many orchards. Various degrees of leaf mottling from a faint chlorosis to distinct patterns including chlorotic rings and blotches with or without necrotic spotting occurred in all but one orchard. The cause of these abnormalities has not yet been determined.

Cherry yellows virus was present in all of the 21 sour cherry orchards surveyed. Symptoms were apparent for only a short period, and the amount of leaf fall was less than usual. Necrotic leaf spot virus was found in only nine orchards. The shock-symptom phase of this disease, the result of new infections, was found in five orchards.

A comparison of the symptoms produced on peach by the cherry yellows virus with those produced by the prune-dwarf and necrotic ring-spot viruses, respectively, suggest that the prune-dwarf virus, in combination with the necrotic ring-spot virus, may cause symptoms of cherry yellows on Montmorency. It should be pointed out that every case of cherry yellows so far investigated appears to be associated with the necrotic ring-spot virus. At least every source of the yellows virus has produced, in addition to the yellows phase, a sequence of symptoms similar to those associated with necrotic ring-spot. Accordingly, a series of inoculations were made with two strains of the prune-dwarf virus, and two strains of the necrotic ring-spot virus, singly and in combination on Montmorency sour cherry and Italian prune. With one strain of the prune-dwarf virus (PDE) in combination with either of the two strains of the necrotic ring-spot virus, symptoms typical of cherry yellows were obtained on Montmorency. The prune-dwarf virus alone produced typical prune-dwarf symptoms on Italian prune. With the other strain of the prune-dwarf virus (PDY) in combination with the same two strains of the necrotic ring-spot virus, negative results were obtained. In this case, however, the prune-dwarf virus itself gave no reaction on Italian prune. These results, though by no means conclusive, indicate that certain strains of the prune-dwarf virus in combination with certain strains of the necrotic ring-spot virus, may produce symptoms of cherry yellows on Montmorency. Whether all cases of cherry yellows are due to a combination of strains of these viruses is still an open question.

A study of the insect fauna present in commercial orchards of sour cherries by the Division of Entomology, has been one phase in the search for possible insect vectors of cherry yellows and necrotic leaf spot viruses. Six species of cherry insects were used for inoculation tests on cherry seedlings. On a few of these seedlings colonized with *Typhlocyba rosae* and *Myzus cerasi*, there developed a fine line type of necrosis and ring spotting of the leaves, resembling the shock symptoms of cherry yellows. These experiments will be repeated.

Mild rugose mosaic has been found so far only on two trees of Black Tartarian sweet cherry and is of no economic importance at the present time. The symptoms on sweet cherry are a delay in foliation, the unfolding leaves being

wavy at the margins, puckered, stunted, misshapen and distorted, with chlorotic spots, rings, partial rings, bands, and some necrosis in the centre of the chlorotic areas. This disease has been transmitted by budding to Napoleon sweet cherry, Montmorency sour cherry, peach seedlings, the peach varieties Elberta and Rochester, and *Prunus mahaleb*. Transfers were also made to Lombard plum and Italian prune, but no symptoms were obtained on these hosts.

Grape Diseases.—Downy mildew failed to develop this season and no data were obtained from the extensive spray experiment. Chlorosis was a prevalent disorder, which received attention. The most effective treatment for it proved to be foliage sprays containing 1 or 2 per cent iron sulphate. Three days after the application, chlorotic vines showed improvement and continued to improve during the following two weeks. Recovery was more rapid and complete with the stronger solution. Some response was obtained with applications of manganese sulphate, but this salt was much less effective. The reappearance of chlorosis on some vines in the latter part of the season suggested that repeated applications of iron sulphate are necessary.

The prevalence of dead arm in Concord vineyards is a matter of concern to grape growers. A preliminary investigation revealed that one reason for its prevalence is the failure of the grower to detect all infected vines and to mark them for pruning or removal during the dormant season. In one vineyard, 42 per cent of the infected vines were over-looked; some of these vines bore extensive disease lesions and had undoubtedly been infected for a number of years.

Raspberry Anthracnose.—A study, at Ottawa, of the nutritional requirements of *Elsinae veneta*, the cause of anthracnose of raspberries, showed that the fungus can be isolated from lesions on raspberry canes, grown on a raspberry leaf extract agar, and made to produce conidia in sufficient quantity for inoculating large numbers of raspberry seedlings when the seedlings are inoculated under suitable conditions (15°C and 95 per cent relative humidity) with a suspension of the conidia. They will show definite macroscopic symptoms of the disease in from two to three weeks.

The raspberry trial plots at Kentville were sprayed with a delayed dormant spray of 1 per cent Dinitrosol followed by an application of ferbam (2 lb. to 100 gal.) when the new canes were twelve inches high to control anthracnose. This treatment greatly reduced the disease in 1948, but late-season spread produced lesions on susceptible varieties for the winter carry-over. Excellent control was again obtained during the early part of 1949 on all varieties, but during the fall a late spread occurred again on the susceptible varieties, Ottawa, Taylor, and Washington. No lesions were found on the resistant Viking and Newburg. In a trial planting of fifteen varieties of red raspberries at St. Catharines, anthracnose was conspicuous only on the more recently introduced varieties, except Ottawa. Washington, Taylor, and Rideau were extremely susceptible and, where these varieties are grown, a spray control program must be adopted. It is significant that Viking and Latham, the most widely grown varieties, were free of infection.

Raspberry Inspection and Certification.—The annual inspection of raspberry plantings for certification of planting stock was carried out for twenty-six growers. Four plantings in a total of ninety-eight were rejected because of the incidence of virus disease and, in addition, plantings of ten growers because of poor vigour of cane or serious mixture of varieties. Plantings of twelve growers met the inspection requirements for certification, and a list of these growers was made available for distribution. To prepare for the taking over of the certification of raspberries by the Provincial Fruit Branch, a provincial inspector assisted with the inspection this year.

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Cane Gall of Blackberries.—The host range of *Agrobacterium rubi*, the cane-gall bacterium, is wide if based upon prick or wound inoculations and includes broad beans, garden peas, bush beans, sweet pea, and sunflower. The organism survives for a much shorter period in artificial culture and in competition with soil organisms than does the crown-gall bacterium, *A. tumefaciens.* These characters, coupled with its inability to enter plants except through wounds, may possibly provide the reason why in nature it appears to be confined to *Rubus* spp. The organism has been found only on Himalaya blackberries in British Columbia, on which host it causes serious damage to the fruiting canes. The absence of galls on current-season canes is due apparently to failure to gain entrance, for, upon artificial inoculation, the current-season canes are equally as susceptible as the fruiting canes, if not more so. On a common host, the galls produced by *A. rubi* are distinct in appearance from those produced by *A. tumefaciens*, and the tissue of the former possesses a greater tendency to break down than that of the latter. The distinctiveness is particularly striking on sweet pea plants.

Leaf Diseases of Strawberry.—Four fungi were isolated in 1949 from diseased strawberry leaves; namely *Mycosphaerella Fragariae* causing leaf spot; *Diplocarpon Earliana*, leaf scorch; *Dendrophoma obscurans*, leaf blight; and *Zythia Fragariae*, leaf blotch. It is believed that this is the first record of leaf blotch in North America.

Field surveys in Ontario revealed that leaf spot was most prevalent in the spring and fall, whereas leaf scorch increased in severity during the warmer months. Leaf blight was most evident after the cropping period. Varietal resistance to leaf spot and leaf scorch was also observed. Among the more common varieties grown in Ontario, Louise was very susceptible to leaf spot, Senator Dunlap moderately so, Fairfax and Temple showed only a trace, and Premier was very resistant, even when growing next to a severely infected variety. The varieties Fairpeake and Red Wing were heavily infected with leaf scorch, Louise, Temple, and Valentine moderately infected, Senator Dunlap occasionally showed lesions, and Premier, Tupper, and Culver were resistant.

In cultural and infection studies, the optimum temperature for the production of spores on leaves and for growth in culture of *M. Fragariae* was about 77°F., whereas that for spore germination was about 60°F. Premier plants, resistant to the fungus in the field, proved susceptible when tested in the greenhouse. In all varieties tested, lesions were produced only on middle-aged leaves, namely, those that had just become fully expanded. It was found that infection of leaf tissue could take place at a temperature from 50° to 68°F., but that symptoms did not appear below that of 60°F.

Diplocarpon Earliana was isolated with difficulty. The addition of strips of strawberry leaves to a suspension of spores enhanced their germination, for which the optimum temperature was from 77° to 86°F. This temperature range was also optimum for symptom expression, which occurred only on fully mature to old leaves.

Infection studies with *Dendrophoma obscurans* indicated that the age of the leaves and the condition of the plants as a whole may determine the amount of infection taking place. It appeared to attack mainly old leaves, and at their margin. The *Zythia Fragariae* was usually found associated with the leaf blight fungus, but further studies are required to determine the extent of its parasitism.

Strawberry Virus.—Yellows of strawberry has become a serious problem in the Pacific Northwest on the Marshall variety. Up to the present, British Sovereign, which is the main variety grown in British Columbia, has not been seriously affected. Whether this is due to the British Sovereign stocks having so far escaped infection or to a natural tolerance of this variety to the disease is not known.

Results of this year's investigations at Vancouver into the etiology of the disease indicate that yellows is the result of multiple infection by two or more separate virus components, a condition paralleling that found in Great Britain with a similar disease known as yellow-edge. By permitting the aphid vector to feed for different lengths of time on diseased plants and then for varied lengths of time on healthy plants, it has been possible to separate at least two components from the virus complex.

The first component produces a mottling, crinkling, and leaf distortion in *Fragaria vesca*, but it has not, up to the present, produced any symptom in the British Sovereign variety. This component does not persist in the aphid for longer than six hours. Work on the second component is still in its preliminary stage. The component seems to require a much longer incubation period, for the symptoms did not appear until several months after the plants of *F. vesca* were inoculated. The symptoms are an upward cupping of the young leaves, a slight marginal chlorosis, and a gradual degeneration of the plant, with the older leaves dying and the younger ones becoming progressively smaller. As with the first component, no symptoms have as yet appeared on British Sovereign.

Crop Inspection and Seed Examination for the Control of Seed-Borne Diseases

Seed Examination.—The health condition of 517 seed stocks has been determined at Ottawa by laboratory test during the year, including 235 Foundation, 54 Registered, 161 Certified, 32 commercial, and 35 unspecified seed samples. The number of samples for the different crops were as follows: Beans 66, cereals 4, clovers 13, corn 49, flax 13, grasses 11, peas 57, sunflower 4, swedes 25, tobacco 13, vegetables 227, and miscellaneous 35.

Methods of Diagnosis for Seed-Borne Diseases.—The development of a method for testing bean seed for the presence of common and of halo blight has been undertaken at Ottawa in co-operation with the Division of Bacteriology. The application of the phage-lysis technique of diagnosis with certain modifications has given promising results.

The determination of Ascochyta infection of pea seed by a method requiring only a period of soaking of the seed and macroscopic examination offers a simple laboratory diagnosis, with the possibility of providing also a method of obtaining small lots of disease-free seed by hand selection.

Seed Health Approval Plan.—In all, 253 acres of beans, grown for seed under the Health Approval Plan in British Columbia, were inspected in the field for freedom from bacterial blights in co-operation with Plant Products Division; 117 acres were approved. The crop on 33 acres has now passed the necessary 2-year inspection and is eligible for registration as Health Approved seed.

Under the Health Approval plan, 41 fields of peas and beans were inspected in eastern Ontario for disease. Inspection of 107 Foundation crops for disease was made in the vicinity of Ottawa, including crops grown by the Cereal, Horticulture, and Forage Crops Division.

In order to determine the effect of seed treatment on both suitable and unsuitable seed, 157 samples of beans and peas were tested in field trials. The results clearly indicated the beneficial results of seed treatment even in seed judged to be suitable by laboratory examination.

Use of Antibiotic Substances as Seed Treatments for Disease Control.—An attempt has been made to control bacterial blight in beans by means of seed treatment with certain antibiotic substances. Although the bactericidal and bacteriostatic action of a number of antibiotics were promising, none of them proved to be satisfactory in the actual treatment of bean seed.

Of a number of antibiotic substances tested as seed treatments for the control of leaf and pod spot of peas, at least one has been found to be satisfactory under greenhouse conditions. This represents the first successful application of an antibiotic seed treatment in the control of a seed-borne fungus disease.

Diseases of Ornamental Plants

Nematode Diseases.—Evidence has been obtained at Saanichton that the control of the bulb nematode of narcissus by the standard hot water-formalin three-hour treatment is only effective when the proportion of pre-adults to eggs and other stages is low.

From the experimental evidence obtained it was concluded that infection by the bulb nematode, *Ditylenchus iridis,* takes place only through the basal tissues of the bulbs and stems in the iris variety Wedgewood. The evidence also suggests that an examination of the base of flowering stems that ripen prematurely, may reveal the extent or distribution of a field infestation.

The chrysanthemum leaf nematode, *Aphelenchoides ritzema-bosi,* from field-grown chrysanthemums has again been successfully established on plants of *Lilium longiflorum* var. Croft. The symptoms on lilies caused by this nematode was distinct from those caused by the leaf nematode, probably *A. olessistus,* that naturally inhabits the Croft lilies in the Victoria area.

Intercepted Shipments of Imported Nursery Stock.—Samples were examined for disease from 230 variety lots out of 175 shipments comprised of plants belonging to 45 genera. Nearly all the shipments were from Holland and the United States. Tulips, gladioli, irises, hyacinths, and narcissi, in descending order, made up most of the specimens. Penicillium rot of tulips, perhaps stimulated by poor weather for curing the bulbs after harvest in Holland, was unusually serious, being found in 22 shipments and attacking up to 26 per cent of the bulbs. Other diseases seen frequently were: Penicillium rot and nematode rot of iris; fire and mechanical injury of tulip; yellows of hyacinth; Penicillium rot and scab of gladiolus; basal rot of hyacinth; and Rhizopus rot of begonia, caladium, calla and gloxinia, which is seldom severe but frequently destroys up to 10 per cent of these fleshy tubers.

Treatment of Cuttings.—Dipping the cut bases of holly cuttings in either Arasan, Fermate, or Spergon dust increased the percentage that rooted and survived. A further increase was effected by adding a trace, 10 p.p.m., of naphthalene acetic acid to these dusts.

DIVISION OF CHEMISTRY

Animal Nutrition

Nutritive Value of Cattle Rations.—An investigation was made of the effect on digestibility of feeding cattle high levels of rations containing either barley—a carbohydrate concentrate, linseed oilmeal—a protein concentrate or oats—a coarse grain. The basal ration was hay. When the oilmeal was fed at maximum levels there was a small loss of from 2 to 3 per cent in the total digestible nutrients per 100 lb. of dry matter. There was no decrease in the digestibility of protein. When barley was fed at maximum levels there was a marked decrease of approximately 10 per cent in the total digestible nutrients and a substantial decrease in protein digestibility of about 7 per cent. When oats were fed at high levels of feeding the results were intermediate between the oilmeal and the barley. The decrease in total digestible nutrients was about 5 per cent, whereas the decrease in protein digestibility was between 3 and 4 per cent.

Nutritive Value of Swine Rations.—An investigation was carried out to determine whether there were any associative effects between the component feeds of the Canadian Advanced Registry swine testing ration. This ration is composed of the basal grains, barley, wheat and oats, together with a protein-mineral concentrate, containing 50 per cent of tankage. Digestion trials were carried out on mixtures of barley and tankage in varying proportions, on mixtures of barley, wheat and oats in varying proportions with a constant amount of the protein mineral supplement and on the grain mixture and the protein supplement in varying proportions. In this latter ration the proportions of the grains to each other were kept constant. In none of the cases was there any associative effect. The nutritive value of each individual component did not change regardless of the proportion in which it was fed in the ration.

A study has been initiated on the effect of variations in the fibre content of rations on their nutritive value. The plans call for the use of three different types of fibrous feeds, alfalfa meal, bran and oat feed. The investigation on alfalfa meal has been completed. It was fed to swine in varying proportions with barley as a basal ration. The alfalfa meal itself had a low nutritive value, total digestible nutrients of the dry matter being 25 per cent. However, its inclusion in increasing quantities in the ration did not in any way affect the digestibility of the barley. It was concluded that while the fibre content of a particular feed may cause it to have a low nutritive value, it does not affect the digestibility of other components in the ration.

Evaluation of Canadian Feedstuffs.—The survey of the nutritive value of Canadian feedstuffs has been continued. Attention has been given particularly to the meals from oil-bearing seeds. Digestibility trials have been carried out with both swine and cattle on sunflower seed oilmeal, rapeseed oilmeal and mustard seed oilmeal. Preliminary results indicate that sunflower seed oilmeal has a higher value than rapeseed which in turn has a higher value than mustard. Comparing these results with previous ones on linseed oilmeal and soybean oilmeal, it would seem that the mustard seed oilmeal has a lower feeding value than the other oilmeals tested. This work is being continued.

A second investigation dealt with wood sugar yeast which at the present time is produced in only limited quantities. This is made by growing bakers' yeast on waste sulphite liquor from pulp companies. An experiment was commenced last year to compare the feeding value of this yeast with ordinary brewers' yeast. Preliminary results on cattle indicate that, if anything, the wood sugar yeast had a lower value than the brewers' yeast.

The Conservation of Herbage.—The economics of production of meat, milk and other products in Canada depend to a large extent upon the nutrients supplied by herbage. This Division and the Division of Field Husbandry of the Experimental Farms Service have been carrying out a series of co-operative experiments to determine the best method of conserving herbage so as to maintain the nutritive value at as high a level as possible. The criterion for nutritive value has been the content in digestible nutrients. The following treatments were given to herbage which was predominantly clover,—artificially dried, cured under ideal conditions, cured under various adverse conditions, winter-stacked, cutting after the proper stage of maturity and ensiled.

When the herbage was cured under ideal conditions the product had a nutritive value only slightly less than when it was artificially dried. Herbage which was cured under adverse conditions had a value only slightly lower than that cured under ideal conditions. However, when the crop was allowed to go beyond the proper stage of maturity it suffered a definite loss in nutritive value. When it was ensiled its energy value was no higher than that of the crop cured in the field.

On the basis of the last three years' results it is not recommended that herbage in this locality be ensiled unless weather conditions are adverse. A second conclusion is that even when conditions are not ideal it is better to cut the hay at the proper stage of maturity than to leave it in the field beyond this stage.

Stability of Iodine in Iodized Block Salt.—It has been previously reported that the potassium iodide now used in iodized block salts is unstable under pasture conditions. The iodine is quickly lost. Experiments have been carried out using potassium iodate, dithymol iodide and "iodine complex" prepared by Merck & Co. Potassium iodate was stable. The thymol iodide rapidly lost half of its iodine content and then remained fairly stable. The iodine complex was quite unstable. Further experiments are being carried out to determine if the iodine in potassium iodate is available to the animal.

Toxicity of Sodium Chlorate.—Sodium chlorate is used in commercial weed killers for roadsides and under bushes. A question arose as to a possible danger to cattle that might graze sprayed areas. Experiments showed that sodium chlorate is highly toxic. However, when applied according to the direction of the manufacturer and when the necessary precautions are taken, it was concluded that there should be no danger to livestock.

Fatty Acids in the Sheep Rumen.—The stable isotope C^{13} and the radio-isotope C^{14} are being used to study the metabolism of carbohydrates in ruminants. One of the main pathways of this metabolism is through the formation of the volatile fatty acids, acetic, propionic and butyric by the fermentation processes in the rumen. Such acids are being prepared with isotope tracers in their structure. They will be administered to sheep. Before these experiments can be carried out it is necessary to obtain information concerning,—*(a)* the relative proportions in which these acids occur in the paunch, *(b)* the rapidity with which they are formed and *(c)* the effect of the nature of the ration on their relative proportions.

An experiment has been initiated in which sheep will be provided with a rumen fistula. Different types of rations will be fed, samples will be removed from the paunch at different intervals and the relative proportions of acetic, propionic and butyric acids determined. During the last year a satisfactory technique has been worked out for the separation of these three acids from the paunch contents and for their quantitative determination.

Studies on Nitrogen Metabolism.—Further trials were carried out in which urea containing N^{15} was fed to sheep. The rate of excretion of N^{15} in the urine at unit intervals has been plotted against time and the distribution of N^{15} in various fractions of the body has been determined. L-lysine containing N^{15} in the alpha-amino group has been synthesized. It will be fed during the coming year in a manner similar to that of urea. Further amino acids labelled with isotopes will be prepared and administered to ruminants.

Vitamin and Physiological Research

The unit undertakes fundamental research on biochemical and physiological aspects of vitamins and hormones together with standard assays of vitamin supplements submitted by inspectors working under provisions of the Feeding Stuffs Act. The work is carried on as a co-operative project of the Experimental Farms, Production, and Science Services. The report of the standard assays is given in the section dealing with Laboratory Services, Production Service. The experimental findings are reported here.

Vitamin D.—The object of these studies is to elucidate the mode of action of vitamin D. Chickens have been used principally as the experimental animals, and so far the work has been restricted to the growing period when bone growth and calcification are proceeding most rapidly. Studies have been made of the movement of calcium and phosphorous administered orally or parenterally, and the effect of vitamin D on these movements. For this purpose, radioactive isotopes of calcium and phosphorous have been employed.

Localization of calcium and phosphorous has been made by using radiochemical, x-ray and autoradiographic techniques. Mineral deposition has been followed mainly in the tibia, in the tibio-tarso metatarsal articulation and in the phalanges of the foot. Celloidin embedding and stripping film techniques have been followed for autoradiographs.

It was reported a year ago that in starving chicks vitamin D prevented the loss of calcium from the bones. Additional experiments have been conducted with birds fed *ad libitum*. After administration of an oral dose of radio-calcium, approximately 2 per cent of the activity was retained in the rachitic tibia at the end of 15 days. With the non-rachitic tibia, however, the retention exceeded 5 per cent. When the calcium was administered by the intramuscular route, over 6 per cent of the activity was recovered in the tibia of both rachitic and non-rachitic chicks. The movement of calcium from the bones was determined by comparing the amount of Ca^{45} in the toe of one foot with that in the similar toe of the other foot of the same bird some days later. When vitamin D was not a limiting factor, there was no significant difference in the radio-calcium content of the two toes, even after 15 days. The total calcium content of the toes increased with time, and the specific activity fell as a result of the dilution of Ca^{45} with Ca^{40} from the diet.

Vitamin A.—Carotene is found abundantly in nature and can be obtained in a relatively pure state. It is converted to vitamin A in the animal body, and as such has an important physiological function.

Experiments were conducted to study the conversion of carotene to vitamin A. The site of conversion is of prime interest to biochemists. One phase of this study in these laboratories dealt with the absorption of carotene and vitamin A from wax pellets implanted subcutaneously in rats. It was found that whereas vitamin A was absorbed by this route and exerted a physiological effect, carotene did not. The *in vitro* degradation of carotene to vitamin A was also studied. Conditions were found which resulted in yields up to 25 per cent. This is a significant advance, as previously reported yields have not exceeded 1 per cent.

Paper chromatographic techniques were investigated for the determination of small amounts of vitamin A. This was a necessary adjunct to the identification of vitamin A in the *in vitro* conversion from carotene. The method has been developed to the point where it is possible to recover over 90 per cent of the vitamin A in a sample, and to identify amounts as low as 2—5 μg.

This laboratory undertakes the vitamin A tests on animal feeding oils which are regulated by the Feeding Stuffs Act. Vitamin A acetate is now the Canadian Standard, and the Morton-Stubbs correction has been proposed for official adoption. This correction is based on the linearity of the absorption of extraneous substances over the wavelength region 313 to 338·5 mμ. It has been found in these laboratories that this absorption is not always linear. A method has been worked out, therefore, which enables one to calculate the absorption characteristics of the extraneous substances in an oil sample.

Vitamin B Complex.—Vitamin B_{12} and the animal protein factor (APF) have become of prime interest during the past year. The importance of these factors in agriculture lies in the possibility of utilizing vegetable protein supple-

ments to a greater extent. APF supplements can be used to supply certain nutritional factors previously provided only in animal protein supplements. It is, however, necessary to maintain the total protein content of the diet at previously prescribed levels as APF will not replace protein.

The assay of vitamin B_{12} may be done by either microbiological or biological techniques. Several substances interfere with the microbiological method, and great care has to be exercised to ensure the adequacy of the culture medium for other factors, and the purity of the test samples. Such rigid conditions are not so important in the biological assay, but up to the present the most commonly employed criterion of response has been the growth or body weight increase of experimental animals. This is a notoriously variable expression of physiological activity, and is affected by a variety of conditions. Studies being undertaken in these laboratories are designed to explore other physiological or biochemical changes which are affected by vitamin B_{12} or APF administration, with a view to providing a more sensitive and specific criterion of response.

The importance of cobalt in the diet of ruminants appears to be linked with the synthetic processes which occur in the digestive tract of these animals. Experiments are being undertaken with sheep having rumen fistulae to determine what role cobalt plays. The nutritional factors of particular interest in this study are vitamin B_{12} and APF.

Hormones.—Studies have been continued on the effect of thyroxine, of other thyroid-active substances such as iodinated protein, and of goitrogens on chickens and experimental rats.

Respiratory metabolism trials were undertaken with rats, using a closed circuit technique in which carbon dioxide in the animal chamber was absorbed with soda lime and oxygen was introduced from a large burette in which water replaced the oxygen to maintain atmospheric pressure. Controlled feeding of experimental animals proved more staisfactory than *ad libitum* feeding in the determination of resting metabolism, and the method shows promise of being useful as a regular assay technique.

The effect of thyroid active substances on blood iodine values, and the quantity of thyroxine iodine in circulation have been studied. Technical difficulties in the chemical determination are being overcome successfully.

Tests have been initiated on the goitrogenic properties of seeds of *Brassica spp.* Rape seed oil has become of some economic importance. The meal may possess certain undesirable qualities, and these are being studied with a view to designing methods for their correction.

Synthetic estrogens have been suggested as an ingredient in fattening rations for poultry, because of their effect in improving the "bloom" of dressed birds. The extent to which these estrogens remain in the fat is an important point to consider.

In co-operation with the Poultry Division, estrogen assays with rats were conducted on the fat removed from birds which had received synthetic estrogen during the fattening period. With one of the synthetic estrogens, there was very little residual activity left in the fat.

Miscellaneous.—Veterinary inspectors in meat packing plants occasionally see carcasses in which the bones have a brownish red colour. The condition has been ascribed to osteohaemochromatosis, in which haematoporphyrin is deposited in the bones. Specimens submitted by the Animal Pathology Division have been examined spectrophotometrically, and the pigment identified as uroporphyrin. Live animals were not studied, as the condition has not been recognized in Canada until the time of slaughter. Inspectors have been asked to be on the watch for animals which pass red urine or which have coloured teeth. If live animals are obtained it is planned to study them to see if the condition corresponds with congenital porphyrinuria (pink tooth) which has been reported from South Africa.

Food Investigations

The main work of the Food Investigation Unit has been the chemical control and investigation of processed foods, manufactured in establishments licensed by the Department of Agriculture, to maintain standards of grade and quality. Some 14,486 samples were examined in the year under review.

Meat Products.—Service for the Health of Animals Division required analyses of 780 samples of packing house products and materials used in their production. The work this year has included a survey of the cereal and moisture content of sausages and other prepared meats manufactured in all inspected establishments throughout Canada. In co-operation with the Division of Bacteriology samples from import shipments of gelatin for use in food were analysed for conformity to the requirements of the Food and Drug Regulations.

Fruit, Vegetables and Maple Products.—Service for the Fruit and Vegetable Division included the analysis of 724 samples such as jams and jellies, tomato products, pickles, sauerkraut and canned products for conformity to standards under the Meat and Canned Foods Act. Out of 200 samples of suspected maple syrups and sugars forwarded for examination under the Maple Sugar Industry Act, 69 were found to be adulterated or to be imitation maple products.

Dairy Products.—Service for the Dairy Products Division required the analysis of 11,899 samples of whole and skim-milk powders for conformity to grade specifications for fat and moisture content. Quality control of other dairy products has included the analysis of over 350 samples of various products such as processed cheese, condensed and evaporated milk, ice cream mixes and casein

Egg Products.—The Division continued to co-operate with the Special Products Board in the analysis of samples of all shipments of dried egg powder to the United Kingdom under agreement with the British Ministry of Food. Up to the termination of the contract at the end of 1949 a total of 178 samples of A and B grade powders were analysed. All samples were found to meet the required specifications.

Plant Chemistry

Mineral Nutrition.—Tissue analysis data from a survey of Ontario orchards showed satisfactory nutritional levels in almost all cases. Comparisons of results of analyses on extracts of fresh and dried tissue indicated that the two sets of results could not be used interchangeably, there being only a general correspondence. Analysis of potato petioles from fertilizer experiments showed a fairly high correlation of soluble tissue phosphorus with available soil phosphorus in the early stage of growth. This correlation disappeared as the fertilizer began to reach the roots. A light broadcast of one of the new type of detergents gave a slight increase in yield and a marked increase in the average weights of well-developed roots in both sugar beets and mangels.

Composition and Keeping Quality of Apples.—McIntosh apples from plots fertilized separately with nitrogen and phosphorus were analysed after being stored for several months. At the same time samples were rated for keeping quality by the Division of Horticulture. Compounds of nitrogen and phosphorus were separated into various fractions. There was no relationship of keeping quality with any of the fractions or with ratios of these fractions to each other. Increasing rates of nitrogen fertilization did not cause a corresponding increase in nitrogen in the fruit, but a progressive decrease in total phosphorus content was found. Increasing rates of phosphorus fertilization caused no consistent change in nitrogen or phosphorus in the fruit.

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Harvesting Maturity of Peas and Corn.—Studies were carried on with a view to establishing a simple chemical field test for determining the optimum stage of maturity for harvesting peas and corn. Changes in moisture, starch, sugars, soluble phosphorus and vitamin C were too gradual to serve as an indication of maturity progress. Promising results were obtained based on a colour change using a silver salt with boiled extracts of the peas and corn. The studies will be continued.

Rutin in Buckwheat.—Analyses for rutin content were made on 22 selections of buckwheat grown by the Cereal Division. Rutin content varied from 2·85 to 4·65 per cent of the whole dried plant. The yield per plant, which is the factor of commercial interest, varied within narrower limits. There was in general a fairly marked increase in rutin content over that of similar plants grown in 1948. The differences between selections were not uniform enough in the two years to decide as to the best selection and further work is required.

Coumarin in Sweet Clover.—The selection of low-coumarin plants, desirable from an animal-feeding standpoint, is being carried on by the Forage Crops Division. Analyses were made on leaves from 30 plants with results ranging from a trace to 0·44 per cent of the dry weight. An extensive chemical survey of selections is to be made during 1950.

Blackening of Potatoes upon Boiling.—Potatoes from fertilizer plots gave an indication that the condition was associated with low potassium in the soil as has been found at times by others. Tests for several chemical constituents in the tubers failed to establish any relationship with blackening. The copper content of blackened material has consistently been lower than that of white portions in the same tubers. The addition of a trace of copper to the boiling water has caused blackening on normally white potatoes. Potatoes grown under conditions reported to aggravate the blackening and potatoes from various localities will be used in 1950 experiments.

Plant Breeding.—Sixty varieties of oats chosen to represent a wide range of types, and grown at Ottawa, Winnipeg, Scott and Agassiz have now been analysed for two crop years. There was a marked variation between varieties in both years, amounting to 145 per cent for protein and 235 per cent for fat. This emphasized the importance of considering the chemical composition in addition to yield and disease resistance when selecting commercial stock from breeding trials. Locality was also an important factor in determining composition, variations in protein between stations being of a magnitude comparable with that between varieties. There was a smaller difference due to the year in which grown.

Cereal Studies.—Data for the protein content of wheat and barley from sequence experiments at the Lethbridge Experimental Station were analysed statistically. There was no significant difference in Lembi wheat grown after beets, beans, peas, potatoes, corn, fallow, barley or wheat. The protein content of barley following fallow was significantly greater than following beets, peas, beans, potatoes, barley or wheat. Barley following peas, corn or potatoes had a significantly greater protein content than when it followed beets or wheat. In barley variety trials no significant differences were found in the protein contents of Glacier, Trebi and Velvon.

Oil Seeds.—Chemical investigations on 23 flax selections and varieties have been made on material grown at Lethbridge by the Cereal Division. When grown on irrigated land both their total oil and iodine number were slightly higher than when grown on dry land. Yields on irrigated land were almost triple those on dry land.

A summary has been made of 5 years of flax-seed work at 11 localities. By stations the oil content on a dry-matter basis ranged from 39·0 to 41·9 per cent. Iodine numbers varied from 184 to 196. The yearly means were between 39·1 and 40·9 per cent for oil content and 184 and 190 for iodine numbers.

Insecticides.—Parathion, a new and very effective insecticide, is extremely toxic to warm-blooded animals. Greenhouse studies were undertaken on several aspects of its use. The findings were as follows: (1) Parathion soil treatments had no effect on the germination of seeds of vetch, oats or lettuce, and no visible effects on height, colour or general vigour of the plants. (2) After 118 days the quantity of parathion in the soil from treatments of 2 and 12 lb. per acre was negligible. In the 100 lb. treatment it was reduced to the equivalent of 10 lb. (3) There was no apparent effect on the nitrate nitrogen of the soil, indicating that parathion had not affected the nitrate-forming bacteria. This was confirmed by the Bacteriology Division. (4) The Bacteriology Division compared the total numbers of bacteria, actinomycetes and fungi present in treated and untreated soils. Except for a brief period at the beginning of the experiment there was no observable effect on the abundance of a number of micro-organisms usually found in the soil. (5) Some toxic material, which may or may not be parathion, was found in the plant tissue. Calculated as parathion this amounted to a maximum of 0·25 p.p.m. A bio-assay method using the fruit fly was evolved for this problem, since chemical methods were not sensitive enough.

Parathion analyses on cauliflower, apples and peaches under ordinary spraying conditions showed residues well below the unofficial tolerance of 1·5 p.p.m.

DDT residues on pears, apples and peaches were generally less than the suggested tolerance of 7 p.p.m.

Lead and arsenic on sweet and sour cherries were less than the unofficial suggested tolerances of 7 p.p.m. lead and 3·5 p.p.m. of arsenic calculated as arsenic trioxide. Apples sprayed according to recommended spray schedules were well below this tolerance in lead and arsenic.

Analytical Service.—In addition to its own projects and co-operative projects with other Divisions the Plant Chemistry Unit provides an analytical service for projects which are the primary concern of other units of the Division or of other government agencies. The following samples were examined: (1) 1,200 samples for feed constituents mainly in connection with Animal Nutrition studies; (2) 1,780 samples in connection with plant breeding and nutritional studies of the Botany and Plant Pathology, Animal Husbandry, Poultry, Forage Crops, Field Husbandry, Tobacco and Cereal Divisions; (3) 11 samples of dehydrated foods for the Department of National Defence; and (4) 375 samples for Marketing Service.

Advisory Service.—As a service to farmers 60 samples of hay, silage and other farm products were analysed for feed constituents, minerals or carotene. When necessary, appropriate advice was given in regard to the farmers' problems.

Soils and Fertilizers

Soil Colloids.—Greenhouse studies on laboratory-treated samples of a brown soil from Saskatchewan and an upland podsol soil from Quebec were continued for a second year. Yield data on the first year's greenhouse crops (oats and alfalfa) have been obtained and samples of the crops have been retained. The second year's crop will be treated in the same way. Yield and composition of these crops will be studied in relation to the colloidal composition of the soils after treatment.

Soil Organic Matter.—Three soils, a chernozem from Lacombe, Alta., a dark brown soil from Scott, Sask., and the A horizon of a podsol from Lennoxville, Que. are under study. The soluble organic matter from a large sample (3 kg.) of each soil has been divided into five fractions. The distribution of the organic matter among the various fractions was similar in the two western soils but a different distribution was found in the eastern soil. A considerable amount of work has been done to adapt the technique of paper partition chromatography to an investigation of the amino acid content of these soil organic matter fractions. In a peat soil, proline, hydroxyproline, glycine, alanine, histidine, valine, aspartic acid, glumatic acid, threonine and phenylalanine have been tentatively identified.

Fertility Studies on Soil Types.—In the greenhouse, oats and alfalfa have been grown on a number of soil types for two successive years. The potassium content of the oats (grain and straw) was determined in both years. The percentage of potassium in the straw from most of the soils receiving a 4-10-0 treatment was considerably less in the second year of the experiment than in the first year. This low potassium content in the second year corresponded with a marked response in oat yield where potassium was applied. In the first year of the experiment, the oat crop showed little response to applied potassium on these soils.

Soil Reaction.—In 1931, an experiment was begun by this Division at the Experimental Station at Charlottetown, P.E.I., to determine the effect of increasing rates of ground limestone on potato scab development and red clover yields in a three year rotation of potatoes, barley and clover. In 1948, soil samples representing each plot in the area were taken and examined to study the effect of the limestone applications on the composition of the soil.

A study of the crop yields over the nine-year period 1940 to 1948 inclusive (three complete rotations) showed that increasing rates of limestone had no effect on potato yields and only during the last two or three years was there any noticeable amount of scab developing and then only where the higher rates of limestone were applied. The barley yields showed some increase where the lower rates of limestone were used whereas, with clover, the yields increased progressively as more limestone was applied.

Examination of the soil samples showed that the reaction had been progressively increased from pH 4·9 to pH 6·0 where the rate of application was 3,000 lb. per acre. Similarly the amount of exchangeable calcium was increased from 2·41 to 6·05 milliequivalents per 100 grams and the base saturation was increased from 31·5 to 66·6 per cent.

Micronutrients.—In connection with the above experiment at Charlottetown on the effect of rates of application of ground limestone on potato scab development and red clover yields, a study was carried on to determine the effect of the limestone applications on the solubility of manganese. Exchangeable manganese was determined on the soil samples collected from the various treatments in 1948. On the plots receiving no limestone, the pH values averaged 4·9 and the exchangeable manganese was 20 p.p.m. Mn. Where the plots had received 1,500 lb. ground limestone per acre at intervals during the course of the experiment, the soil samples had a reaction of pH 5·5 and contained 14 p.p.m. exchangeable Mn. At the highest rate of ground limestone used (3,000 lb. per acre), the pH was increased to 6·0 and the exchangeable manganese was only 9 p.p.m. Mn. Thus increasing rates of limestone brought about a gradual increase in soil pH and this resulted in a decrease of exchangeable manganese.

Soil Mineralogy.—A petrographic examination of the sand fractions of eight horizons of a brown podsolic soil from Blandford, Que., showed that the main

minerals occurring in the heavy fractions were hornblende and basaltic hornblende, several types of garnet, substantial amounts of zircon, tourmaline, enstatite and smaller quantities of approximately forty other heavy minerals. In the lighter fractions, quartz, feldspar and micas predominate. Electron micrographs of the silt and clay fractions showed that little, if any, kaolinite was present. This soil, therefore, appeared to be quite different from samples of North Gower clay, Rideau clay and Regina clay previously examined by this method.

Pure samples of five clay minerals have been secured from several localities in the United States: (1) kaolinite from South Carolina, (2) allophane obtained near Bedford, Indiana, (3) bentonitic montmorillonite from Osage, Wyoming, (4) halloysite from near Bedore, Indiana, (5) illite from Fithian, Illinois. A standard procedure has been devised for obtaining dehydration curves and such curves have been prepared for the above five minerals.

Dehydration curves have been prepared for the clay fraction of four of the eight horizons of a Blandford profile and through comparison with the type curves and electron micrographs, it has been shown that montmorillonite is the clay mineral most prevalent with illite in secondary position, and slight occurrences of kaolinite in two horizons.

Methods of Analysis.—In the fusion analysis of soil samples, it was recently observed that, in some cases, erroneous results for magnesium were obtained due to the presence of large amounts of manganese. The filtration of the combined magnesium-manganese precipitate was improved by using a platinum Gooch crucible and a perforated platinum disk. The ignited precipitate was readily dissolved in hydrochloric acid and the manganese determined colorimetrically after the removal of the HCl with H_2SO_4. Special precautions must be taken in the filtration and in the ignition of the precipitate.

Soil Erosion.—Preliminary investigations in 1947 indicated that the amount of eroded material collected in the run-off tanks could be measured much more rapidly by a specific gravity method. This method has now been tested over a period of two years. By means of a specific gravity bottle and a balance accurate to 0·1 gm., measurements can be made quickly and accurately. In comparison with the usual method, which consisted of evaporation and subsequent oven-drying of a weighed sample of suspension, the new method saves a great deal of time, equipment and laboratory space.

Waste Sulphite Liquor.—In the preparation of wood pulp by the sulphite process, huge quantities of the waste sulphite liquor are obtained annually in Canada. This liquor contains considerable amounts of lignin sulphonic acids together with smaller quantities of other organic materials and is usually discarded.

Recently, an experiment was concluded to determine the effect of waste sulphite liquor solids, obtained by evaporation of the liquor, on certain chemical and physical properties of the soil. Comparisons were made with untreated soil and with soil treated with manure. Increases in the moisture content and ignition loss of soils treated with waste sulphite product were greater than in the case of manure-treated soils. Water-soluble organic matter was increased considerably by this material treatment, especially in the case of a sandy soil. This treatment also brought about an increase in the percentage moisture equivalent and in the size of the water-stable aggregates.

Soil Survey.—At the request of the National Soil Survey Committee, a study of the methods used in soil laboratories in Canada was undertaken. The Committee submitted a group of 17 samples to ten different laboratories for analysis. The determinations carried out by this laboratory included:

colour, field texture, mechanical analysis, reaction, moisture, loss on ignition, carbon, silicon, aluminum, iron, phosphorus, calcium, magnesium, potassium, sodium, base exchange capacity and exchangeable bases. In addition, total analyses of 17 samples and certain determinations on 5 samples, obtained by the British Columbia soil survey party, were made. Work was also continued on samples submitted in connection with soil formation and profile development studies.

General Fertility Studies.—In connection with field experiments conducted by other Divisions and Branch Farms, the following samples were examined: (1) Six samples for the Division of Botany; (2) 27 samples from the Division of Horticulture: (3) 71 samples from the Division of Illustration Stations; (4) 186 samples from Ste. Anne de la Pocatiere, Que.; (5) 96 samples from Normandin, Que.; (6) 34 samples from Charlottetown, P.E.I.; (7) 17 samples from Beaverlodge, Alta.; (8) 6 samples from Nappan, N.S.; and (9) 6 samples from Lennoxville, Que.

Advisory Service.—A total of 510 samples of soil, 19 samples of limestone and marl, 1 sample of manure, 2 samples of fertilizer, 2 samples of peat moss and 1 sample of sewage sludge were received for examination from farmers, gardeners and others interested in agriculture. Reports as to general fertility and recommendations in regard to the use of fertilizers were made in the case of the soil samples. Composition and possible agricultural value were reported in the case of the other samples.

Branch Laboratories

KENTVILLE, N.S.

Soil Fertility Studies.—Studies conducted in the Aldershot experimental orchards clearly demonstrated the value of mulch in moisture conservation and soil tilth. An orchard fertilized heavily with hen manure fortified with "Stable-Phos" showed abundance of plant nutrients. Levels of ammonia nitrogen and nitrate nitrogen were high throughout the season, ranging from 70 to 10 p.p.m. for ammonia nitrogen and from 100 to 25 p.p.m. nitrate nitrogen during the season's growth. Leaf nitrogen varied from 2·90 to 2·13 per cent. This high content of soil and leaf nitrogen showed the nitrogen supply to be in the "luxury" range. It was reflected in excessive tree terminal growth, large apples and poor keeping quality of the crop.

Soils from the permanent pasture experiment conducted by the Division of Illustration Stations showed varying fertility. Phosphorus was found to be localized in the top two inches of soil.

The copper content of peat soils obtained from bogs in the province varied from 32 to 50 p.p.m.

Insecticides and Fungicides.—In soil studies on the cumulative effects of insecticides and fungicides used in orchard spraying four test crops were used, namely—carrots, potatoes, beans and buckwheat. Four spray materials were tested—parathion (15 per cent), lead arsenate, DDT powder (50 per cent) and powdered sulphur. These were incorporated into the soil prior to planting. The crops were analysed at harvest time for possible absorption and translocation of the spray materials.

Some parathion was found on the surface of carrots, 0·70 p.p.m. and some was absorbed in the surface layer, 0·21 p.p.m., whereas a central core showed none. Potatoes showed 0·20 p.p.m. on the surface and 0·02 p.p.m. in the inner tissue. Green bean pods contained no parathion. Buckwheat plants contained 0·11 p.p.m.

Arsenic was found in three of the crops, beans containing none. Carrots contained 0·58 p.p.m., carrot tops 0·282, buckwheat 0·178 and potatoes 0·008. The translocation to the carrot tops was of interest and indicated that caution must be exercised in feeding carrot tops from a crop grown on soil contaminated with arsenic.

DDT was present in beans and carrots in traces only, with carrots having a slightly greater amount.

Soil concentrations of parathion, arsenic and DDT showed only a slight decrease by the end of the season. This is in contrast with Ottawa greenhouse studies on parathion where the disappearance was fairly rapid.

Sulphur treatments lowered both the percentage germination and the yield of carrots. The sulphur, however, was readily oxidized in the soil. Other treatments did not affect yields.

Parathion was not detected in a survey of market samples of apple sauce and apple juice for spray residues of parathion and arsenic. The arsenic content (calculated as arsenic trioxide) of the sauce ranged from nil to 0·014 p.p.m. and of the juice from 0·09 to 0·27 p.p.m.

SUMMERLAND, B.C.

Phytochemical Investigations.—Analyses for calcium, phosphorus, manganese, iron, magnesium and potassium were made on samples of apple leaves in connection with studies on "leaf scorch", a condition that is widespread in the Okanagan Valley in British Columbia. A positive correlation was found between the potassium: magnesium ratio and the incidence of this disorder. No correlation was noted between the incidence of leaf scorch and the other elements which were determined.

Studies on chlorosis were continued. Iron compounds were (1) placed in holes made in the ground with a crowbar, (2) dissolved in water and the solutions sprayed onto affected trees, and (3) placed in holes bored into the trunk. Only the latter method gave a satisfactory control.

A black necrotic spot on fruit and a dying back of young twigs on apricot were studied. It was shown that the dying back of the twigs was associated with an extremely high boron content. Some doubt still exists as to the cause or causes of the black spots, as the results of a series of analyses indicate that although the two disorders were sometimes found on the same trees, affected fruit did not always contain an unusually high amount of boron.

Insecticides and Fungicides.—Field studies on high-speed concentrate sprayers were continued with special attention to the uniformity of deposit when the trees were in the dormant and full-foliage stages. In the dormant period two commercial machines were assessed by the uniformity of oil deposits on the upper and lower parts of apple and cherry trees. One of these machines, the Besler "Beskil" steam aerosol generator employed high pressure steam as the atomizing agent. The other machine, the Canadian-built Okanagan Turbo-Mist sprayer, atomized the concentrate spray liquid by hydraulic pressure. Both units dispersed the atomized concentrate in a high velocity airstream, and both were developed directly from the Okanagan experimental sprayer, a machine designed by this laboratory. These machines gave considerably higher deposits than thorough hand spraying, although they applied only 75 per cent as much toxicant per acre as applied by hand. From this year's investigations it appears that for concentrate machines the per-acre dosage of toxicant in the dormant period should be in the order of 50 per cent of the amount normally applied by hand spraying.

When the trees were in foliage the performance of the machines was assessed by determining parathion deposits on leaves and fruit. In addition to the machines tested with dormant sprays a hydraulic-blower concentrate machine (Besler "Bes-Spray") and two blower attachments for conventional sprayers (Besler "Bes-Blo" and "Turbo-Trailer") were tested with summer sprays. Although satisfactory pest control was obtained with all machines, spray coverage was not so uniform throughout large trees as is desirable. The amount of toxicant required for summer sprays with concentrate machines was only slightly less than that required for good hand spraying. No excessively high DDT deposits were found in orchards sprayed by concentrate machines.

Analyses of parathion residues on apple foliage indicated that the addition of lime sulphur, wettable sulphur, dinitro-o-cyclohexylphenol or stove-oil had no appreciable effect on the persistence of that compound. Parathion disappears rapidly from foliage. The rate of disappearance seemed to be the same on the north and south sides of the tree, in pink and summer sprays and in orchards in different localities of the Okanagan Valley. The harvest residue on apples sprayed with three times the recommended amount of parathion was 0·2 p.p.m. which is considerably less than the suggested tolerance of 1·5 p.p.m.

Fruit and Vegetable Products.—Analysis was made of 858 samples submitted by the inspectors of the Marketing Service to help in setting grade standards and controlling the quality of processed materials. Work was also carried out for the Fruit and Vegetable Products laboratory at the Station and for the Canned Foods Association of British Columbia.

SAANICHTON, B.C.

Chelate Complexes as Seed Protectants.—A number of insoluble metalo-organic complexes (chelates) were prepared, and the most fungistatic of these compounds tested as seed protectants. The mercury complexes of cupferron (ammonium nitrosophenylhydroxylamine) and of phenylthiohydantoic acid effected better control of radish seedlings against damping off by *Pythium ultimum*, than did Arasan, a standard seed protectant fungicide. The copper complex of phenylthiohydantoic acid gave the same degree of control as Arasan, while the zinc complex of the same compound, and the cadmium, lead and chromium complexes of cupferron were somewhat lower in effectiveness.

The Physiology of Phytophthora Species.—A detailed study was made of carbon and nitrogen requirements of *P. parasitica*, in connection with the use of this organism in the microbiological assay of thiamin. Sucrose and maltose were best sources of carbon, followed by glucose, fructose and mannose. Pentoses, alcohols, organic acids and glycoside failed to support growth of the fungus. The diamino-dicarboxylic group of amino acids from hydrolysed casein proved to be the best nitrogen source, although very favourable growth was obtained also from the mono-amino carboxylic acid group.

Trace element requirements of *P. parasitica* were found to be iron 1 p.p.m., zinc 1 p.p.m., copper ·05 p.p.m., and manganese ·05 p.p.m. Other essential trace elements not yet identified appeared to be present in well water.

The respiratory activities of *P. parasitica* are being investigated by means of the Barcroft respirometer. Multiple mycelial pellets from shake cultures proved very active for use in the respirometer. Addition of carbohydrate inhibited respiration, at least for a period of several hours. A pH of 5·9 appeared most favourable for oxidation. Dinitrophenol at 0·001 molar concentration greatly stimulated endogeneous respiration, while at 0·01 molar inhibition took place. Sodium azide at similar concentrations produced slight

inhibition. The respiratory quotient both in the presence and absence of carbohydrate was 1·05 indicating that the mould storage products are possibly carbohydrate in nature.

Attempts are being made to identify metabolic by-products by the paper chromatographic technique. An unidentified reducing substance has been found in 10-day cultures with an Rf value smaller than that of glucose or fructose. Organic acids were separated which have not been identified, but are distinct from oxalic, acetic, formic, lactic, succinic, fumaric, maleic, tartaric or citric acids. Metabolic filtrates were found free of all amino acids except asparagine, which was a component of the original medium.

DIVISION OF ENTOMOLOGY

The activities of the Division of Entomology were materially affected in 1949-50 by the serious grasshopper outbreak in the Prairie Provinces, the vexing questions of root maggots and aphids attacking vegetables, the increasing importance of mites in orchards, the continuing menace of bud-worms in the forests, and the problem of biting flies in northern areas. To contend with these and other insect hazards, extensive surveys were maintained in the forests, in the arctic barrens, and in agricultural regions threatened by specific pests; investigations of new insecticides and improved methods of application were intensified; studies of the biology of major pests were extended, especially upon the factors affecting insect behaviour and survival; and the taxonomic section of the Division was enlarged to improve the identification service and to advance basic knowledge of the insects of Canada. During the year, entomological service was extended to Newfoundland; the Stored Product Insect Investigations Unit established an office at Vancouver, B.C.; the Field Crop Insect Investigations laboratory at Lethbridge, Alta., was transferred to improved quarters; a new header-house and greenhouse were erected at Chatham, Ont.; the construction of the Laboratory of Insect Pathology at Sault Ste. Marie, Ont., was brought near to completion; a laboratory for the investigation of diseases attacking insect pests of agricultural crops was opened at Kingston, Ont.; and improved research facilities were provided for several entomological groups in the Science Service Building at Ottawa.

Field Crop Insect Investigations

Investigations on the value and use of new organic insecticides constituted one of the major activities of Field Crop Insect Investigations in 1949-50, although biological studies and the research on insect-resistant plants were continued in increased volume. Many of the new insecticides are extremely toxic to insects, but some of them are also dangerous to handle or must be used with extreme caution to prevent contamination of foodstuffs. As biological knowledge of the insects is the foundation on which most control recommendations are based, detailed studies on life-history, ecology, nutrition, and responses to environmental factors constituted an increased proportion of the research program.

Grasshoppers.—The grasshopper outbreak in the Prairie Provinces was more widespread and serious in 1949 than for some years past. Saskatchewan was more seriously affected than Alberta or Manitoba, although grasshoppers were far more abundant in Manitoba than they were in 1948. The control campaigns were very successful, chlordane being used as the poison in baits, sprays, and dusts.

Investigations on insecticides introduced in 1949 showed that aldrin when used at 2 ounces or dieldrin at 1 ounce per acre was more effective than chlordane at 8 ounces. Unfortunately, both aldrin and dieldrin are extremely toxic to warm-blooded animals, and dangerous to handle.

Grasshoppers were again abundant in eastern Ontario and Quebec, particularly in the St. Lawrence River Valley. Though not so abundant or widespread as in 1948, they caused some losses in fields and gardens when they moved out of meadows after the hay had been harvested.

At Saskatoon, Sask., valuable data are being obtained on the time and conditions under which chemical control of grasshoppers is most effective. Nutritional studies at Lethbridge, Alta., are providing important leads in a cereal breeding program to develop grasshopper-resistant varieties.

Wireworms.—Investigations on wireworm control at Saskatoon, Sask., Victoria, B.C., and Chatham, Ont., showed that benzene hexachloride, either worked into the soil or applied as a seed dressing, will protect crops from immediate damage by wireworms, as well as reduce the wireworm numbers. Chlordane is not so effective as benzene hexachloride but may be used on crops that would be tainted by benzene hexachloride. One treatment of either insecticide followed by the proper cultural methods will hold wireworms below economic numbers indefinitely.

Wheat stem sawfly.—The wheat stem sawfly seems to be developing a more rapidly maturing strain that is causing losses in winter wheat, according to investigations at Lethbridge, Alta. Biological and cytogenetical research is being conducted to prove whether this is a strain or a nutritional variation.

Cytogenetical research on sawfly-resistant wheats is materially advancing the breeding program being carried on co-operatively by officers of the Lethbridge laboratory and the Experimental Farms Service. Though the resistant wheat, Rescue, which is being grown at present, is greatly reducing the annual losses caused by this insect, progress is being made toward the development of a more resistant variety of considerably better quality.

White grubs.—Investigations on white grubs at Marmora, Ont., showed that a spray of benzene hexachloride, applied to the surface of the soil, will destroy the grubs and prevent sod destruction. The dosage is so heavy that the treatment is too expensive for use in pastures but is of value in controlling white grubs in parks, lawns, golf courses, and nurseries.

Where the sod has been destroyed by white grubs, immediate cultivation with a disk harrow and seeding the land to fall rye gave an excellent pasture for the rest of the summer, prevented soil erosion, and reduced weed growth.

European corn borer.—At Fredericton, N.B., Golden Sunshine and Golden Bantam varieties of sweet corn were significantly more resistant to corn borer infestations than any other of the six varieties commonly grown. At Chatham, Ont., of 113 lines of inbred and hybrid corn studied, a few exhibited a high degree of tolerance. On a few single crosses on which many eggs were laid very few larvae became established.

At Chatham, parathion was the most effective insecticide tested for the control of the European corn borer, being considerably better than toxaphene. At both Chatham and Fredericton, methoxychlor was ineffective. Chemical analyses of stalks, husks, cobs, and ears showed that the parathion residue was below the tentative U.S. limit for materials used as livestock or human food.

Greenbug.—A serious outbreak of the greenbug occurred in Manitoba, southeastern Saskatchewan, and southern British Columbia during the first two weeks of July. Approximately 100,000 acres of late oats and barley were destroyed in Manitoba. This insect apparently migrated from the southern United States, causing serious losses in North Dakota and South Dakota. Experiments at the Brandon laboratory showed that a parathion spray was very effective in reducing the numbers of aphids.

Sweet clover weevil.—At Brandon, Man., studies on the sweet clover weevil showed that the natural mortality of the larvae is apparently much greater in sandy soils or heavy clay loam than in the more common clay loams. Sweet clover grown on clay loam is more severely injured than that grown on a heavy clay loam, whereas that grown on sandy soil is comparatively free of injury. In southwestern Ontario the sweet clover weevil seriously damaged sweet clover, whether grown as a forage crop or as a honey crop.

Green peach aphid on tobacco.—The sudden severe outbreak of the green peach aphid on tobacco in southwestern Ontario in 1948 was followed by a similar but not so widespread outbreak in 1949. The most severe infestations occurred in areas within five miles of Lake Erie and adjacent to peach orchards, indicating that the aphid develops more rapidly in humid areas and is a more serious menace to tobacco grown near the winter host plants.

Sugar-beet root aphid.—For the first time since sugar beets have been grown in southern Alberta, the sugar-beet root aphid was sufficiently abundant in 1949 to cause a serious loss in yield and sugar content. In addition to direct losses, beets infested with the root aphid were more susceptible to frost, and suffered extensive damage on September 9, when the temperature dropped to 23°F. Uninfested fields were not damaged and yields were as expected.

Effect of barometric pressure upon oviposition of the imported cabbageworm.—In laboratory experiments in Manitoba, caged adults of the imported cabbageworm laid more eggs under low than under high barometric pressure. These data and observations in the field suggest that a definite increase in oviposition takes place when the barometric pressure is low. Barometric pressure also appears to be a major factor in migration; during periods of high pressure, the butterflies are very active and fly long distances. Hence, alternating periods of high and low pressure would tend to disperse the population and promote egg-laying over wide areas.

Root maggots attacking vegetables.—Chemicals tested in British Columbia, Prince Edward Island, and Newfoundland for the control of maggots attacking turnips, of which there are four major species in Canada, generally gave less than economic control. Parathion and aldrin, the most effective of the materials tested, gave fairly good control but at impractical rates of application.

At Victoria, B.C., chlordane and benzene hexachloride dust or spray each gave excellent control of the cabbage maggot on cabbage, chlordane spray being the most effective of 8 insecticides. In a heavy infestation in New Brunswick, benzene hexachloride, parathion, chlordane, and corrosive sublimate each gave unsatisfactory control of the cabbage maggot on cabbage. At Ottawa, where radish was used as a test plant, parathion dust, benzene hexachloride spray or dust, chlordane spray, parathion spray, and toxaphene dust were much more toxic to the cabbage maggot than were calomel, corrosive sublimate, DDT, methoxychlor, or DDT sprays or dusts.

Studies on the biology and control of the onion maggot were conducted in British Columbia, Alberta, Manitoba, and Quebec. In western Quebec chlordane dust gave promising control for the second year, and parathion dust gave excellent results in the first year's test.

Five years' data on the susceptibility of nine commercial varieties of onions to the onion maggot in eastern Ontario indicated no definite resistance in any of the nine varieties.

At St. Jean, Que., there was no diapause in the first generation of the onion maggot, all the pupae giving rise to adults; only 35 per cent of the second-generation pupae and none of the third-generation produced adults in 1949. In the

laboratory during the winter, the adults were fed on yeast, bread, molasses, and condensed milk. The flies laid no eggs until they had fed on the yeast and milk. Optimum conditions for egg-laying were: soil slightly moistened, humidity over 70 per cent, and temperature about 80°F.

In the first infestation of the carrot rust fly recorded in the interior of British Columbia, ethylene dibromide, applied in 1948 as a soil fumigant along with benzene hexachloride as a top dressing, killed almost 100 per cent of the pupae in a garden at Salmon Arm. At Agassiz, B.C., benzene hexachloride dusts gave varying degrees of commercial control when applied with rotary hand or power dusters, but not so good control as when applied with a hand shaker. Airplane dusting was the least effective method of application.

In preliminary tests at Bradford, Ont., in co-operation with the staff of the Ontario Agricultural College, parathion spray gave excellent control, and aldrin and dieldrin gave good control, of both the first and second generations of the carrot rust fly. As in 1947 and 1948, chlordane gave good control of the first generation; and it is now recommended for the control of the first generation, although it is ineffective against the second generation.

Tuber flea beetle and tainting of potatoes by benzene hexachloride.—At Agassiz, B.C., gamma benzene hexachloride gave control of the tuber flea beetle comparable with that of other years, preliminary examination of tubers showing very satisfactory commercial control. The chemical was either incorporated into the soil at planting or dusted on the foliage. At the time of digging, no taint could be detected in the tubers. However, when benzene hexachloride was used both on the foliage and as a soil fumigant the potatoes were definitely unpalatable in the spring of 1949. Further, potatoes grown in 1949 in southwestern Ontario in a field treated in 1948 with benzene hexachloride against wireworms showed no off-taste or odour when freshly dug. After storage in bags until September, the tubers had a definite taint, indicating that tainting may develop in storage.

Toxicity of benzene hexachloride and chlordane to mammals.—In tests arranged by the Dominion Animal Pathologist, white rats and guinea pigs were fed potatoes from fields treated with benzene hexachloride or chlordane at Chatham, Ont. The animals were healthy throughout the test, but pancreatic lesions of possible significance were found in post-mortems of the group fed on the chlordane-treated potatoes.

Aphids attacking potato.—DDT emulsion applied to potato at weekly intervals after July 15 materially reduced the spread of potato leafroll in experimental plots in New Brunswick, but there was still a small percentage of infection despite the fact that very few aphids were present. The infection apparently resulted from the feeding of the few dispersing aphids that found their way to the new foliage produced in the periods between the applications. Parathion gave no better protection than DDT.

An aphid trap was operated in each of 10 potato-growing areas in Quebec, from July 15 to September 15. Of 2,200 aphids caught, 65 per cent were the potato aphid, 24 per cent the buckthorn aphid, 9 per cent the green peach aphid, and 2 per cent the foxglove aphid. The aphid population was highest in the district of Ste. Anne de la Pocatiere. Few aphids were caught in the Gaspe Peninsula.

Aphids that attack potato were caught in traps on a ferry crossing Northumberland Strait, midway between Prince Edward Island and New Brunswick, confirming that the aphids are carried by air currents at least 5 miles, and that they may be carried from New Brunswick to Prince Edward Island. Similar findings had been made for aphids of other species on the same ferry in 1948,

but this is the first demonstration in Canada that aphids which attack potato can migrate for several miles.

Colorado potato beetle.—In a co-operative project with the Division of Botany and Plant Pathology, 230 lines of Mexican and South American potatoes from the Commonwealth Potato Collection at Cambridge, England, were tested for resistance to the Colorado potato beetle in greenhouse tests at Ottawa. The most promising varieties must be tested further to determine that they actually have inheritable resistance.

Tomato hornworm.—In southwestern Ontario, bait-trap captures indicate that males and females of the tomato hornworm occur in about a 1:1 ratio. It was confirmed that moths native to Ontario are larger than those of the same species in Tennessee. Because moths collected in Ontario after August 31 are markedly larger than the Tennessee moths, autumn migration from as far south as 37° latitude appears improbable.

Leafhoppers attacking beans.—Bean plants sprayed with DDT in southwestern Ontario were as vigorous as unsprayed plants, but reductions in yield resulted when the DDT was applied to very young plants. Harvest records did not support the impression gained from tests in 1947 and 1948 that routine treatment with DDT of white beans not severely infested with leafhoppers would result in greater yield.

Onion thrips.—Weekly applications of 5 per cent chlordane dust gave exceptionally good control of the onion thrips in three successive years in southwestern Ontario. Five per cent DDT dust has given very satisfactory control in four successive years. In 1949, a parathion spray gave extremely satisfactory results.

DDT residue on celery.—In Manitoba, DDT residues on celery resulting from seasonal applications of DDT dust for the control of the tarnished plant bug increased with the rate of application, and were greater at the bases of the leaf-stalks than at the tips. Residues on the leaf-stalks close to the heart were relatively low; those at the bases of the middle and outer stalks, higher. When the outer leaves were discarded and the plants were washed, the residues remaining were within the limits of the tentative U.S. tolerance.

Insects attacking foliage of cabbage.—Three seasons' data have shown that if the first application is made about July 20 almost complete mortality of the imported cabbageworm, the cabbage looper, and the larva of the diamondback moth on late cabbage in eastern Ontario can be secured with four applications of 3 per cent DDT dust, in a year of average infestation; good control, with three applications; and fairly good control, with two applications. The dates recommended are July 20, August 2, 15, and 30. Single applications are not recommended.

Dusts of 2 per cent tetraethyl pyrophosphate (TEPP), 2 per cent nicotine-lime, and 2 per cent parathion gave excellent control of the cabbage aphid at Victoria, B.C. Under the conditions on Vancouver Island, TEPP dust is evidently the most promising insecticide for the cabbage aphid.

Varietal responses of cucumbers to DDT and Methoxychlor.—Three per cent dusts of technical-grade DDT, high-setting-point DDT, and methoxychlor, tested for the control of the striped cucumber beetle at Ottawa, were applied 8 times at weekly intervals to 12 varieties of cucumbers. Technical-grade DDT injured all varieties tested, especially 6 varieties that appeared particularly susceptible to technical-grade DDT in 1947 and 1948. High-setting-point DDT

was only slightly less injurious to the latter 6 varieties than was technical-grade DDT, but it appeared reasonably safe for the 6 varieties that were tolerant of technical-grade DDT in 1947, 1948 and 1949. Although methoxychlor appeared safer than either form of DDT on all varieties tested, the data indicated that it should be used with caution on young plants, or on plants grown under glass.

Fruit Insect and Insecticide Investigations

Among the more important projects carried on by the Fruit Insect and Insecticide Investigations Unit during the year were the extension of trials of concentrate sprayers to Eastern Canada; investigations on orchard mites, including trials of new acaricides and studies of the biologies and natural enemies of the various species; continuation of long-term studies on the effects of spray materials on the fauna of apple and peach orchards; tests of new insecticides, expecially parathion, against many pests of fruits; biology and control of the oriental fruit moth, especially the effects of weather conditions; control of the narcissus bulb fly; and investigation of insect transmission of virus diseases of cherries. The outstanding development in the insecticide field in 1949 was the widespread use of parathion, both experimentally and by growers on a commercial scale. No cases of death or serious illness from its use have been reported in Canada, and it appears that this highly effective but dangerous insecticide can be safely used in orchards if proper precautions are taken, but every opportunity should be taken to impress growers with the fact that carelessness may have fatal results. Investigations have started on systemic insecticides, which are absorbed by the plant through either the roots or the leaves and render the tissues toxic to insects or mites. Tests to date confirm conclusively that octamethyl pyrophosphoramide has very definite systemic action against aphids and the two-spotted spider mite, and 2 additional compounds are highly effective against the latter.

In May, 1949, a position was created in the Fruit Insect and Insecticide Investigations Unit for an insecticide specialist to establish and maintain an organized, up-to-date file of information on insecticides and related materials, and to appraise their effectiveness on the basis of the experimental evidence available in Science Service reports and in the literature. Such information as has been filed to date has been valuable in reviewing applications for the registration of insecticides under the Pest Control Products Act and also in answering inquiries from many sources.

Codling moth.—In British Columbia the codling moth infestation was at a lower level than for many years, largely because of the general use of DDT, but growers have been warned that the capacity of this insect to survive and cause trouble should not be underestimated. The severe outbreak that occurred in Nova Scotia in 1948 has subsided, and injury was generally much lower in 1949, although this insect was still the most important pest of apples in the province. Although DDT was used much more extensively for codling moth control in 1949 and was very effective, it was not alone responsible for all of the reduction that occurred in the majority of Nova Scotian orchards regardless of the spray program and even in unsprayed orchards. Schedules of lead arsenate alone or lead arsenate-summer oil gave good results where a full complement of sprays was applied.

In parts of southern Ontario and especially in the Niagara district, codling moth injury was exceedingly severe, apparently because of the very hot and dry weather, which has long been known to promote heavy infestations. Any program containing fewer than 5 "cover" sprays of DDT failed to give adequate protection, and even 6 allowed too much injury when the sprays were poorly timed or carelessly applied. Results of experimental spraying were not very

conclusive because it was necessary to apply an additional late spray of DDT to all of the plots in one of the main experimental orchards in order to save the owner from serious loss. Lead arsenate used alone failed completely in holding the moth in check. Inclusion of DDT in the first "cover" spray produced better control than where it was not used until the second "cover." A program in which DDT was used at 4 pounds of 50 per cent powder per 100 gallons—twice the usual strength—in fewer applications was promising.

Oriental fruit moth.—Injury to peaches from the oriental fruit moth in Ontario was much lower than for several years, despite the occurrence of 4 generations in 1949 as compared with 3 or 3 and a partial fourth in previous years. The general use of DDT in 1948 may have had some effect in reducing the carryover of moths, and high parasitism in 1949 also suppressed the infestation to a considerable extent, but the chief cause of decline in 1949 was undoubtedly weather conditions. Over many years, seasons such as that of 1949, with warm, early springs followed by hot, dry summers, have been characterized by much lower infestations than cold, backward seasons like 1947 and 1948. On the other hand, very warm weather during the period of third-brood flight in late August and early September, such as prevailed in 1947 and 1948, was responsible for much of the so-called invisible injury, i.e., the presence of larvae in apparently sound fruit of late varieties, which was so troublesome in those years. More moderate temperatures during this period in 1949 helped to hold invisible injury to a much lower level. Drought, which was severe in the Niagara Peninsula, was apparently not alone responsible for the reduced infestation in 1949, as infestation also declined in Essex county, where rainfall was ample.

The light infestation made it difficult to appraise the value of experimental spraying. The schedule generally used in 1949 gave very good control and will be recommended again for 1950. This comprises 2 second-brood sprays of DDT in July followed by an additional application 3 to 4 weeks before harvest except on very early varieties. Four additional early sprays directed against the first brood reduced injury still further but not sufficiently to justify the cost.

Parathion appeared to be at least equal to DDT for control of the first and second broods and was definitely more effective against twig-infesting larvae, but did not always give so good results as DDT in preventing larval entry into fruit approaching maturity.

Studies on the effect of DDT on the parasitism of oriental fruit moth larvae have been inconclusive, results in the Niagara district conflicting with those in southwestern Ontario. Much more work needs to be done on this problem.

Although the oriental fruit moth is well established in the State of Washington, it apparently has not yet entered British Columbia, as no moths were captured in bait traps in the southern Okanagan Valley.

Orchard Mites.—Despite the development of new spray chemicals, several species of mites continue to be the most important pests of fruit in Canada and, with the appearance of new species and extension of the range of those already established, the problem may become more serious. The European red mite is one of the most serious pests of apple, plum, and peach, and is also locally injurious to sour cherry and pear. The two-spotted spider mite is becoming more troublesome in Ontario on both apple and peach, although only a few orchards have been seriously damaged as yet. The Pacific mite, which has been injurious to apple in central British Columbia for several years, was found in 1949 as far east as Manitoba, where it was very serious on a number of fruits in home gardens; it was very serious also on the Pacific coast. Still another species, the Willamette mite, was discovered for the first time in Canada in 1949, attacking apple in the Okanagan Valley.

Parathion was used experimentally on a large scale in 1949, particularly against the European red mite, with variable results. Single applications on established infestations often gave very poor control, 2 or more being usually required to produce lasting effects. In Ontario, 6 ounces of 15 per cent parathion in 4 "cover" sprays on apple gave better control than larger amounts in fewer applications. In general, the highest rate at which parathion was recommended in 1949, three-quarters of a pound of the 15 per cent powder, was barely sufficient to control mites unless it was applied several times, and a somewhat greater dosage might be advisable in some cases. A small quantity of stove oil increased the effectiveness of parathion in British Columbia, but this combination may be too dangerous to the operators. Early sprays timed to kill the first generation of the European red mite before they had laid eggs were promising. For the second year in British Columbia, parathion in the "pink" spray alone on apple controlled the mites for the balance of the season, and equally good results were obtained in Nova Scotia. A similar application in Ontario also produced satisfactory control, but in another orchard where parathion was included in both the "pink" and calyx sprays a considerable population developed during August. In Quebec, parathion in the calyx spray alone gave seasonal control. The use of parathion in early sprays may be restricted in Eastern Canada because of its tendency to injure the foliage of McIntosh and related varieties when applied at this time.

In the Niagara district, parathion in the shuck-fall and "10-day" sprays on plum was very effective against the European red mite, but when used in the shuck-fall spray alone in southwestern Ontario it did not give lasting protection.

In a number of cases in different provinces it was noted that mite populations in the fall and consequent deposition of winter eggs were frequently much greater in parathion plots than in those that had received other acaricides such as dinitro compounds. This was apparently due to the destruction of predators, as studies in Ontario showed that parathion was even more toxic than DDT to predacious insects and mites.

The grower-prepared monoethanolamine salt of dinitrocyclohexylphenol in "cover" sprays continued to give very good results against the European red mite in British Columbia; not only was summer control somewhat better than that given by parathion but also winter egg deposition was lower because of its less harmful effect on predators. In Ontario the salt or its parent dinitrophenol compound has been less effective and is more liable to injure the foliage. The proprietary dicyclohexylamine salt of dinitrocyclohexylphenol (DN-111) again gave fairly good control on peaches in Ontario; a single application was more effective against a heavy infestation than one of parathion.

A new acaricide, p-chlorophenyl p-chlorobenzenesulphonate (C-854), tested for the first time in the field in 1949, produced very efficient control of the European red mite on apple in Ontario, Quebec, and Nova Scotia, and on peach and plum in Ontario. In Nova Scotia C-854 in the "pink" spray alone controlled mites for the rest of the season. A schedule in which C-854 was included in the shuck-fall and "10-day" sprays on plum gave excellent control in Ontario.

Generally 1,1-bis(p-chlorophenyl)ethanol (DMC) was effective on apple but gave poor results in British Columbia. In Nova Scotia, tetraethyl pyrophosphate (TEPP) gave good results when very thoroughly applied in the second to fourth "cover" sprays.

In Quebec, comparison of different types of oils in sprays at the delayed dormant stage did not reveal any advantage of a so-called superior (high paraffinic) oil over the regular heavy oil in the control of the European red mite. In Ontario a "delayed dormant" spray of oil failed to give lasting protection on apple. "Dormant" oil sprays were generally used on peaches and were very effective in delaying the infestation until a summer acaricide could be included in the oriental fruit moth sprays.

The newer dinitro sprays (DN-289, Elgetol 318) based on dinitro-o-secondary-butylphenol generally gave very poor control as "dormant" applications; in particular, a very severe attack of the European red mite followed the use of this material on plum.

Preliminary tests in the greenhouse in Ontario of a large number of new compounds showed that some are very effective acaricides, and the more promising ones will be given field trials next year.

Investigations in the greenhouse in Ontario showed that the addition of solids reduced the effectiveness of summer oil emulsions against mites. Bordeaux mixture had a much greater effect than other materials; for example, where 0·5 per cent oil alone killed practically 100 per cent of the two-spotted spider mite, the addition of bordeaux, ½-1-100, reduced the mortality to 84 per cent and bordeaux, 2-4-100, to 57 per cent.

Life-history studies in Quebec showed that 8 generations of the European red mite developed in 1949, as compared with 7 in 1948. Overwintering eggs were laid by some individuals of the fourth and later generations in both seasons. Seven generations of the two-spotted spider mite were reared in 1949.

Aphids attacking fruit.—A "dormant" application of parathion alone or of parathion-oil was as effective as the standard dinitrocresol-oil spray for the control of the black cherry aphid in British Columbia, and parathion in a spray at petal-fall gave equally good results. This insecticide as a "dormant" spray also controlled the mealy plum aphid in the same province. Summer applications of parathion at three-quarters of a pound of 15 per cent powder per 100 gallons were also effective against this aphid when used early enough, but a higher concentration was evidently necessary on established infestations. In Ontario, three-quarters of a pound in the first "cover" spray on plums gave very good control. In preliminary tests in the greenhouse in Ontario, eggs of aphids on currant and viburnum were very susceptible to parathion. The rosy apple aphid was satisfactorily controlled with parathion applied at the pink and calyx stages in Ontario. When used in the calyx spray alone in Nova Scotia it failed to give any marked reduction, but it was very effective at the delayed dormant stage. The use of parathion in the "pink" spray held the woolly apple aphid under control for the season in British Columbia. In later sprays parathion, nicotine sulphate-oil, and lindane-oil were each effective. Lindane (99 per cent gamma benzene hexachloride), unlike crude benzene hexachloride, has so far not caused tainting of the fruit.

The green apple aphid appeared somewhat resistant to parathion in British Columbia; nicotine sulphate-oil and lindane-oil were each more effective. Parathion also failed to control this species in Nova Scotia even when used at 1 pound of the 15 per cent wettable powder, and nicotine sulphate gave much better results.

Automatic sprayers.—In 1949 there was a great increase in the use of automatic concentrate spray equipment in British Columbia. In 1948 probably 5 per cent of the tree-fruit acreage was sprayed with concentrate sprayers, whereas by the end of the 1949 season upwards of 20 per cent of the acreage was sprayed by this means. Although many owners were able to suggest structural improvements in the machines, they had obtained generally satisfactory control of insects and diseases, and all felt that this type of sprayer was distinctly a forward step in fruit production. Concentrate sprayers gave a saving of about 80 per cent in the cost of labour and up to 50 per cent in the cost of oil at the dormant stage, but gave little reduction in the amount of spray materials for summer application.

With a few exceptions concentrate machines gave good control of apple scab. In the Kootenay Valley, lime sulphur at approximately 2 to 3 gallons

per acre was not sufficiently effective, but lime sulphur at 5 to 6 gallons alone, or at 3 gallons plus 7·5 pounds of wettable sulphur, gave better results in 4 out of 5 cases when applied with the concentrate sprayer than when applied by hand spraying. In the Okanagan Valley, concentrate sprayers applying "dormant" sprays controlled peach leaf curl as well as did hand spraying. Orchard mites and the codling moth were well controlled in apple orchards. It was thought that these machines might not be satisfactory against the woolly apple aphid since it had been assumed that the protective 'wool' of the aphid necessitated drenching spray applications. Experiments revealed, however, that at least 3 different types of concentrate equipment are capable of controlling this pest with either parathion or nicotine sulphate-oil-soap.

In experiments in co-operation with the Division of Chemistry, analyses of oil deposits in the tops and bottoms of large trees showed that concentrate sprayers are considerably more efficient than conventional sprayers in depositing oil at the dormant stage, requiring less than half the amount of oil per acre that is used for thorough conventional spraying. Although the concentrate sprayers have deposited considerably more parathion or DDT than hand sprayers, they have not given any better pest control, presumably because the type of deposit is less efficient. Experiments are now under way to modify the physical characteristics of spray concentrates so as to increase the effectiveness of the deposits.

In 1949 concentrate sprayers were tested in Eastern Canada for the first time. In Ontario, the concentrate machine gave control of apple scab and insects equal to or slightly better than hand sprayers on well pruned trees up to about 30 feet in diameter, but on larger and denser trees it was less efficient. For the control of mites and the oriental fruit moth in peach orchards the concentrate sprayer yielded results equal to those given by conventional machines. The chief disadvantages of the concentrate sprayer were its inability to operate against the winds often prevalent in the early part of the spraying season and the unsuitability of the present model for use among closely set low-headed trees when the branches are borne down by fruit.

In Nova Scotia, comparison between the concentrate and conventional sprayers was made on only part of a season's work and conditions were not conducive to heavy scab infection or serious insect outbreaks, so that results were not conclusive. Nevertheless, it was evident that concentrate sprayers had much to commend them and the tests showed conclusively that they could be used for applying concentrated fungicides to apple trees in Eastern Canada without undue fruit russetting or foliage injury.

Long-term effects of chemicals on orchard fauna.—Studies in Nova Scotia on the long-term effects of the various chemicals used in sprays continued to give interesting information and confirm the results of previous preliminary tests. One of the most important projects is to find a first-rate fungicide that will control apple scab without injuring foliage or fruit and that will not interfere with the biological control of insects to any marked degree. Copper fungicides have been very good in so far as the last factor is concerned but cause too much fruit russetting. A new fungicide, Experimental Fungicide 341-C (glyoxalidine), has shown a great deal of promise but has not been used extensively enough to determine its safety to fruit and foliage under all conditions. With respect to its effect on biological control factors it appears to be innocuous against all the parasites and predators against which it has been tested. There is some evidence that it may destroy red mite eggs, at least when used as a concentrate spray. The results from the test orchard in which this fungicide was used without an insecticide were promising, but not much reliance can be placed on the results obtained from a single year's tests.

The substitution of copper or copper and ferbam fungicides for sulphur in apple orchards has generally brought about a rapid decline in oystershell scale

infestations in Nova Scotia, as a result of the increase of parasites and predators. In parts of New Brunswick the infestation has been reduced much more slowly, apparently because low winter temperatures are fatal to the parasites. Both field observations and controlled experiments have shown that the most important parasite species, *Aphelinus mytilaspidis* LeB., suffers a high mortality at −20°F.

In Ontario, the study of the effects of spray materials on the insects and mites of peach orchards was continued. As in the past, DDT promoted outbreaks of the European red mite, but there is still no evidence, after 4 years, that it promotes infestations of other pests. Parathion was included in the trials for the first time; it proved even more destructive than DDT to predacious forms, especially spiders and chrysopid larvae. A study of the bionomics of the coccinellid beetles belonging to the genus *Stethorus* has been undertaken, as these are among the most important predators of mites attacking peaches and other fruits.

Eye-spotted bud moth.—As in recent years, "dormant" sprays for control of the eye-spotted bud moth gave variable results in the various provinces, presumably because of local climatic conditions. In Norfolk county, Ont., all of several commercial preparations of sodium dinitrocresolate (DN pastes) or triethanolamine dinitro-sec.-butylphenolate (butyl DN) gave good control, although there were reports from other parts of the province that DN paste had not been effective. In Quebec, DN paste was significantly better than parathion at 1 pound of 25 per cent powder in 100 gallons at the late dormant stage. In Nova Scotia, on the other hand, all dinitro materials were much less effective than "dormant" sprays of parathion at 1 to 2 pounds of the 15 per cent powder. At the delayed dormant stage one-half of a pound of parathion gave very good results in this province.

In all provinces from Ontario to Nova Scotia summer sprays of parathion gave uniformly excellent results against this bud moth when properly timed. Best control was achieved when they were applied after the eggs had hatched, somewhat later than the most effective time for nicotine sulphate. Inclusion of bordeaux mixture reduced the efficiency of parathion to a certain extent.

Pear psylla.—Parathion proved to be outstanding for control of the pear psylla in Ontario. Two applications of 15 per cent parathion, at approximately 1 pound in the calyx spray and one-half of a pound in the first "cover" spray, or 3 applications at approximately three-quarters of a pound in each of the calyx and first and second "cover" sprays, held the insect to insignificant numbers throughout the season. Part of the effectiveness of parathion is due to its potent ovicidal action. Conspicuous but not serious foliage injury was produced by parathion when it was applied during extremely hot weather (92°F. or higher), but under more normal conditions it appeared safe.

Parathion likewise gave highly effective control of the pear psylla in British Columbia, as in 1948. Toxaphene was also very toxic to this insect in the same province.

Plum curculio.—In Ontario, parathion at 1 pound of 15 per cent powder per 100 gallons in 2 applications gave better control of the plum curculio on plums than the standard 2-spray schedule of lead arsenate. It was also very effective against a heavy infestation on apricots, killing many of the eggs and young larvae within the fruit on the trees. A low infestation made the results inconclusive on peaches, but parathion appeared to be at least equal to lead arsenate.

The plum curculio occurred in outbreak proportions in most apple-growing districts of southwestern Quebec and many growers suffered serious losses. Lead arsenate alone in the calyx and "10-day" sprays failed to give satisfactory control. The use of parathion in the calyx application followed by later sprays of lead arsenate did not give sufficient reduction in injury.

Blueberry and cranberry insects.—A dust of 3 per cent DDT at 25 pounds per acre gave commercial control of the chain-spotted geometer on blueberry barrens in New Brunswick, but calcium arsenate at 10 pounds per acre had no apparent effect. Against the blueberry thrips, sprays of DDT emulsion or parathion were very effective but DDT wettable powder or nicotine sulphate gave no obvious control.

Three per cent DDT dust was superior to other materials tested for control of the cranberry fruitworm in New Brunswick, being somewhat more effective than cryolite-talc dust. DDT sprays produced much poorer results than dusts, and parathion gave little or no control.

Other stone-fruit insects.—In British Columbia, petal-fall treatments with parathion or DDT applied by concentrate sprayers measurably reduced cat-facing, or deformation and scarring of peaches produced chiefly by the tarnished plant bug. Two applications, at the pink and petal-fall stages, were more effective than one. If spraying is done by conventional hand gun, weeds and cover crop should also be sprayed. Parathion may prove preferable to DDT because it has not so far promoted development of orchard mites.

A scale that may prove to be the cottony peach scale appeared in a number of apricot and peach orchards in British Coulmbia in 1949. It was controlled most effectively with parathion applied during the first week in June.

Parathion applied at the pink stage has given promising control of the peach twig borer in British Columbia. DDT used at the same period has also been effective but seems more prone to bring about increased infestations of the European red mite. Lime sulphur at the pink stage continues to be the standard control.

Other apple insects.—One spray of DDT applied just before the beginning of oviposition gave effective control of the apple seed chalcid in Manitoba.

An application of the regular oil-dinitrocresol spray at the dormant stage gave satisfactory control of a serious outbreak of the cherry casebearer that occurred in apple orchards at Creston, B.C. Parasites have apparently suppressed this pest in the past, 15 different species having been reared from it.

Strawberry insects.—Further experiments on Vancouver Island on the control of white grubs, the larvae of the northwestern June beetle, have substantiated the results of previous years, benzene hexachloride at 1 pound of gamma per acre and ethylene dibromide at 8 gallons of 20 per cent material each giving excellent control. Chlordane at 2 pounds showed definite promise, but DDT at 10 pounds was not satisfactory. Examination of strawberry plants where soil insecticides were originally applied 1 year previously showed that benzene hexachloride had residual control against white grubs but did not reduce a subsequent infestation by the strawberry root weevil. No plants infested by this weevil were found in the chlordane plots. Strawberry plant growth was not affected by benzene hexachloride and was exceptionally vigorous in the ethylene dibromide and chlordane plots.

In experiments in controlling the strawberry weevil in New Brunswick, DDT sprays or dusts again gave the greatest degree of control, although they were apparently applied too early for best results. A spray of parathion had little or no effect. Striking differences in the growth of foliage were evident among plots where various new fungicides were combined with DDT; some fungicides appeared to stimulate growth, whereas others injured the foliage.

In 1949, an outbreak of the strawberry weevil occurred for the first time in Manitoba, but sprays of DDT quickly brought it under control. The same spray also produced a great reduction in injury by the tarnished plant bug and closely related species which cause malformed berries.

Other scale insects.—An oil of so-called superior (high paraffinic) type was somewhat more effective than the standard heavy "dormant" oil in Ontario for control of the oyster shell scale, but the difference was very slight at higher concentrations and 5 per cent of either oil was necessary for good control. In New Brunswick, a "dormant" spray of 5 per cent oil in bordeaux gave distinctly poorer results than the same concentration of an emulsifiable oil used alone. The new type of dinitro spray (DN-289) based on dinitro-o-secondary-butylphenol was effective at the dormant stage in both provinces; used at 2 quarts per 100 gallons it was as good as the older dinitrocresol pastes at 1 gallon. Parathion applied in the calyx spray was very effective in both provinces, but gave much poorer results when it was delayed until the first "cover" spray.

A summer spray of parathion failed to give satisfactory results in the control of the San Jose scale in British Columbia. This pest has also not yielded to summer sprays of DDT, which are effective against the oyster shell scale. Fortunately, control has been very good with the mixture of heavy "dormant" oil and lime sulphur developed in the Okanagan Valley a few years ago.

Narcissus bulb fly.—On Vancouver Island and in the lower Fraser Valley the infestation of the narcissus bulb fly was the greatest ever experienced, being as high as 75 per cent in some plantings where control was not undertaken. Field control tests in which 3 applications of insecticides were used at 2-week intervals were disappointing. Dusts containing DDT, benzene hexachloride (BHC), parathion, or naphthalene gave satisfactory control only when used at excessive rates. Sprays containing summer oil at 1 per cent showed the most promise.

Fumigation experiments with methyl bromide for bulb fly control indicated that first- and second-stage larvae in the bulbs were killed when the fumigant was used at the rate of 3 pounds per 1,000 cubic feet for 4 hours at either 60° or 70°F. and a relative humidity of 70 per cent; and the forcing quality of the bulbs was not impaired. Growers who followed this treatment were well pleased with the results, as no complaints have been received from greenhouse operators who purchased their stock.

Greenhouse insects.—In greenhouses, parathion in aerosol bombs gave very satisfactory results against the two-spotted spider mite and the green peach aphid in Ontario. TEPP aerosols were very effective on the two-spotted spider mite in British Columbia and in Ontario. A light-weight aerosol sprayer in which the pressure is generated by carbon dioxide cartridges, or sparklets, gave good control when TEPP was applied 3 times at 4-day intervals. This machine appeared much simpler and more economical than the proprietary aerosol bomb. A spray of 1, 1-bis (p-chlorophenyl)ethanol (DMC) produced excellent control of the mite on roses but caused severe defoliation.

Virus diseases.—Investigations on the relation of insects to the transmission of little cherry and of cherry yellows have been continued in British Columbia and Ontario, respectively. Although positive evidence that insects are carriers of these virus diseases has not yet been obtained, much has been learned regarding the occurrence and biology of the insects of cherry orchards.

Forest Insect Investigations

The most important contributions made in forest entomology during 1949 consisted of: (1) An increased knowledge of the distribution and economic significance of numerous insect species inhabiting the Canadian forests. This was achieved through expansion and intensification of the Forest Insect Survey. (2) The accumulation of a vast amount of new information on the bionomics

and ecology of the spruce budworm and other important forest pests, such as the larch sawfly, the balsam woolly aphid, and the European spruce sawfly. (3) Advances in the study of the deterioration of timber killed by insects or fire and of the possibilities of salvage of such timber. (4) Development of adequate chemical methods for the control of the bark-beetle carrier of Dutch elm disease. (5) Promotion of the study of insect diseases through the building of a special laboratory for fundamental research on and mass propagation of virus, fungous, and bacterial diseases.

Forest Insect Survey.—The total number of sample collections submitted to the 10 Forest Insect Survey centres in 1949 was 29,255, an increase of 4,640 over that of 1948. This increase in quantity, matched by improvement in quality, is an encouraging sign of the combined interest and of the active participation of the field staff and of the co-operating agencies. All the provincial forest services and many industrial organizations made important contributions. The valuable co-operation of the Entomological Service of the Quebec Department of Lands and Forests and of the Provincial Forest Entomologist of Nova Scotia are gratefully acknowledged.

Maritime Provinces.—In the Maritime Provinces several hundred species of forest insects, both harmful and beneficial, were identified. The European pest known as the winter moth was discovered for the first time in North America, attacking apple, elm, oak, and other trees in Nova Scotia. The elm leaf beetle was found for the first time in the East, defoliating elm. Outbreaks of the spruce budworm appeared in northern New Brunswick, and evidence of mass flights of this destructive species into New Brunswick was obtained. A survey of Newfoundland disclosed that the balsam woolly aphid became established there some years ago, probably as a result of spread from the Canadian mainland. The most destructive insect on the island at the present time is the hemlock looper.

Northern Ontario.—The work of the Forest Insect Survey in northern Ontario reached its highest level of efficiency to date, not only in samples submitted to the laboratory but also in coverage of the forest districts. Considerable information has been gathered on the extent of infestations, the condition of forest stands, and the damage caused by insects throughout northern Ontario. The outstanding features concerning forest insect infestations in northern Ontario include a decline in spruce budworm infestations in most of the areas where severe epidemics have been in progress; continuation of the larch sawfly infestations in northwestern Ontario; and extensive build-up of populations of the forest tent caterpillar in widely scattered parts of the province.

Prairie Provinces.—In the Park Belt of the Prairie Provinces, the Forest Insect Survey yielded considerable information on the abundance and distribution of such major species as the fall cankerworm, the yellow-headed spruce sawfly, the balsam-fir sawfly, and the pine needle scale. The fall cankerworm occurred chiefly in southwestern and central Saskatchewan and the yellow-headed spruce sawfly in the parkland areas of Manitoba and Saskatchewan; the pine needle scale was generally distributed.

An increase in the insect ranger staff made possible the rapid expansion of the Forest Insect Survey in Alberta and the Rocky Mountain National parks. The number of collections increased from 593 in 1948 to 1,773 in 1949, and that of special reports from 14 to 61. Detailed surveys were made of outbreaks of the lodgepole needle miner. A beginning was made in the establishment of permanent sample plots, and sampling techniques have been worked out to provide data more suitable for quantitative measurements of population trends.

British Columbia.—Marked advances were made in 1949 in the Forest Insect Survey of the interior of British Columbia. The increase of the insect ranger staff to 11 men, together with the added interest and co-operation of the field officers of the British Columbia Forest Service, resulted in much better coverage and a very substantial increase in both quantity and quality of the sampling. A total of 3,259 collections were received as compared with 1,887 in 1948. The number of permanent stations for quantitative sampling is now 171.

An intensive survey in the Kamloops Forest District showed that the heavy infestations of the Douglas-fir tussock moth of 1948 had completely subsided. Although several new infestations were located, these also disappeared toward the end of the season. Disease was the primary cause of the decline, but parasites were also important.

Infestations of the mountain pine beetle are active in lodgepole pine in several areas in the East Kootenay District. Outbreaks of this species of bark beetle have also occurred in western white pine in the Revelstoke and Shuswap districts, where, on the recommendation of Divisional officers, several timber sales have been made with the object of salvaging the infested timber and checking the spread of the infestations.

An outbreak of the Engelman spruce beetle found in 1949 in spruce at Bolean Lake constitutes a serious threat to the selectively logged areas and to the adjoining extensive uncut stands. At present, the infestation is confined almost entirely to an isolated uncut stand and to the logged area immediately surrounding it. More than 80 per cent of the spruce 12 inches and over in diameter at breast height, in the centre of the infested area, has already been attacked. The early cutting of the infested timber has been recommended and an investigation is being undertaken to determine the cause of the outbreak and its possible relation to the system of logging now being practised on the area.

In 1949 the satin moth spread eastward from Lytton into the dry belt of the interior. Heavy defoliation of Lombardy poplar occurred near Ashcroft, at Savona, and at Stump Lake. Satisfactory control was obtained at Savona by the application in May of a wettable DDT spray from the ground and a 10 per cent DDT emulsion from the air. This European defoliator is apparently becoming acclimatized to the interior of the province and its recent spread constitutes a threat to the extensive stands of cottonwood and aspen in this region.

Only light to medium infestation of the larch sawfly occurred in 1949, the parasites *Mesoleius* sp. and *Tritneptis* sp. continuing to be important control factors.

A new insectary was established near Victoria to serve as headquarters for the Forest Insect Survey of coastal British Columbia. This structure, located in a natural forest eight miles from the city, was erected on land supplied by the Provincial Forest Service. Increased efficiency of the insect rangers and of the organization of the insectary staff has materially advanced the knowledge of the forest insect situation along the coast of British Columbia.

Spruce budworm.—The spruce budworm outbreak, which has been in progress during the past 15 years, is still the most urgent forest insect problem in Canada, especially in the areas east of the Great Lakes.

New Brunswick.—Intensive studies of the ecology of the spruce budworm and the effects of forest management on its numbers and destructiveness have been continued on the Green River Watershed. This is a long-term project in co-operation with the Dominion Forest Service, the New Brunswick Department of Lands and Mines, and the Fraser Companies, Ltd. The history of the forest of the area has been reconstructed from a study of the present stand and shows that a severe outbreak took place between 1913 and 1918. Damage

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was related to the age and vigour of the stand; severe mortality resulted in stands over 60 years of age, whereas those under 45 years suffered only a loss of increment. Though all the factors influencing susceptibility of the stand are not yet known, it is clear that balsam-fir content and age are of major importance, and a method of making rapid surveys to determine the areas of greatest hazard, by means of aerial photographs, has been worked out.

After several years of experimentation, reliable sampling techniques have been devised for estimating budworm population. The growth and flowering habits of balsam fir have been found to have important effects on budworm survival and on the degree of defoliation. For extensive population sampling measuring larval frass-drop has greatly reduced the labour involved.

An outbreak of the black-headed budworm which developed in 1947 and 1948 was brought to an end in 1949 largely by an increase in larval parasites. The spruce budworm, however, became more abundant. Evidence of the occurrence of mass flights of the latter into New Brunswick was obtained for the first time by means of light traps on lookout towers.

Studies of life-histories and descriptions of immature stages have been completed for a number of budworms associated with the spruce budworm.

Northern Ontario.—The most notable feature of forest insect conditions in northern Ontario was the rather general decline in spruce budworm populations in fairly extensive regions where severe infestations had been experienced in recent years. This was particularly evident in the area surrounding Lake Nipigon, in the area around White Lake, and in the western portion of the Kapuskasing District. However, fairly active infestations persist in the area adjacent to Lac Seul in the Sioux Lookout District and in the eastern portion of the province comprising sections of the Kapuskasing, Cochrane, and Gogama districts. New infestations have built up in comparatively small areas in the southeastern portion of the Algonquin District and on Sibley and Black Bay peninsulas, east of Port Arthur.

Entomogenous fungi associated with the spruce budworm in northern Ontario include *Empusa* sp., *Hirsutella gigantea* Petch, and *Beauveria* sp. However, in no instance was there concrete evidence that the populations had been appreciably affected by the entomogenous fungi. Both the capsule and the polyhedral virus diseases of the spruce budworm occurred widely throughout the province. Very little is as yet known about the capsule disease, but the polyhedral virus has been studied rather intensively. Budworm larvae appear to be very resistant to large dosages of this virus. When larvae are infected in the latter part of their developmental period, pupation frequently occurs and the insects mature, suggesting that the progress of the disease stops at pupation. The results suggest either that the virus disease is of low virulence or that the budworm populations are highly resistant. No convincing evidence is yet at hand that the virus diseases are major controlling factors under field conditions.

Studies of deterioration by insects and by wood-rotting fungi of balsam fir dying as a result of continued defoliation by the spruce budworm were continued in the Black Sturgeon Lake territory as a co-operative project of the Division of Entomology and the Division of Botany and Plant Pathology. Wood-boring insects are the chief cause of deterioration in the first year or more after the death of the tree, and wood-decaying fungi become increasingly important from the second to fourth or fifth year.

Western Canada.—The spruce budworm was found in most of Manitoba, but nowhere, except in the Spruce Woods Forest Reserve, was it present in infestation proportions. The infestation appeared to be dying out in the Reserve. Differences in spring development of the spruce buds may affect defoliation noticeably. The data obtained from 1946 to 1949 on biological control of the

spruce budworm in Manitoba were analysed. There is evidently a rather constant mortality of the budworm, from 86 to 97 per cent, from the time the larvae become established in the spruce buds in the spring to the end of the pupal period. Parasites killed about 25 per cent, predators are known to account for 2 to 20 per cent, and mortality from unknown causes averaged 40 per cent. The latter is believed, however, to be caused mainly by predators. Physical factors are evidently unimportant in this area once the larvae begin feeding. New species of parasites liberated in 1946 and 1947 have not been recovered to date. Indications are that the spruce budworm is slowly declining in the study areas, whereas another defoliator, the spruce needleworm, which also preys on the spruce budworm, is increasing.

The spruce budworm populations in Banff and Kootenay National parks increased alarmingly in 1949. A spray program has been arranged to reduce tree injury along highways and in the vicinity of camping grounds.

Preliminary field studies in 1949 in the interior of British Columbia indicate that, in addition to climatic factors, nutritional factors are important in causing the 2-year life-cycle of the spruce budworm. Extensive infestations of the spruce budworm continue to be active in various stands of spruce and alpine fir in the southern half of the province.

European spruce sawfly.—The European spruce sawfly, which caused widespread injury to spruce in Eastern Canada about 10 years ago, is now under control following the introduction of parasites and of a virus disease. Several species of parasites have become well established and have shown their ability to destroy considerable numbers of the sawfly at low levels of population. The virus has also maintained its effectiveness in relatively small populations but has disappeared from some localities. It is now most general in Newfoundland, where it was artificially established. The virus is being propagated in the laboratory for release in areas where it is not present. The value of these control factors varies from year to year and from place to place, but there is good evidence that in combination they are capable of preventing the widespread outbreaks of the 'thirties.

Larch sawfly.—The larch sawfly continued in moderate to severe infestation throughout northwestern Ontario, and studies of the role of entomogenous fungi were carried out near Vermilion Bay. *Beauveria* sp., although effective in killing experimental populations in the laboratory, gave indifferent results when released in the field. Parasitism of the cocooned larvae of the larch sawfly has remained at rather low levels during recent years. Most of the successful parasites are Diptera, the hymenopteron *Mesoleius aulicus* (Grav.) maturing only occasionally. However, considerable numbers of egg scars of *M. aulicus* are found on larvae dissected from the cocoons, and dead grubs are occasionally found. The evidence at hand indicates that parasites and fungi exert only a comparatively minor influence in the current outbreaks in northwestern Ontario.

In western, central, eastern, and southern Manitoba the severe larch sawfly outbreak of recent years showed signs of abating. The decline is attributed to depleted food supply and an increase in parasites and predators. North and west of this region lies a zone of current maximal abundance, including, in Manitoba, the territory from Mafeking to Sherridon and, in Saskatchewan, the Pasquia, Porcupine, Ft. à la Corne, Nisbet, and the eastern part of the Big River provincial forests. West of this zone to Alberta, the sawfly is widely, but lightly, distributed.

Precipitation and high water levels in tamarack swamps can affect materially the mortality of larch sawfly cocoons in the soil. Excessive moisture during the first half of June would kill a great number of sawflies, as a large proportion of them are then in susceptible developmental stages in the cocoons. On the other

hand, cocoons can resist long periods of flooding prior to June, when they are largely in the dormant, overwintering stage. Newly formed cocoons succumb readily to flooding in 1 to 2 weeks. New cocoons are most abundant in late July and early August. As cocoons age, they develop a resistance which reaches its peak by late September.

Mesoleius aulicus (Grav.), an introduced parasite of the larch sawfly, has not proved effective in the current outbreak in Saskatchewan and Manitoba, for most of the parasite eggs laid in the sawfly larvae fail to hatch. Parasitism occurs when the sawfly larvae are in the third, fourth, or fifth stage. Studies indicate that many eggs fail to hatch because they are enveloped by an encasing membrane formed by the host. This membrane apparently prevents successful development of the parasite embryo in some manner not yet understood. Eggs of the parasite deposited in the fourth or fifth larval stage of the host seem to hatch more readily than those laid in the third stage.

Detailed studies to determine the effect of defoliation of tamarack by the sawfly on the growth habits of the host tree and on the subsequent course of the infestation have been initiated. A number of sample plots and sample trees have been established for a five-year study.

In 1949, an extensive survey for larch sawfly parasites was again conducted in the Prairie Provinces. This survey forms the basis for selecting areas for parasite liberations. Large numbers of three species were released in six areas in Manitoba and Saskatchewan. The effect of these releases will be assessed by future surveys. The most promising native parasite is a fly, *Bessa harveyi* (Tns.). It is relatively abundant in the old infestations but is scarce in newly infested regions.

Lodgepole needle miner.—At the present time, the lodgepole needle miner is the most destructive forest pest in the Rocky Mountain region. The outbreak covers 450 square miles in Banff, Kootenay, and Yoho National parks. The miner is also appearing in considerable numbers in Jasper National Park and in several places on the eastern slope of the Rockies. For the first time in the history of the present outbreak, control by native parasites shows some promise; it varies from 50 to 75 per cent in the older parts of the outbreak area. Two species of parasites of a European needle miner were liberated in Kootenay Park in 1949.

The needle miner population decreases with increasing elevation and is heaviest in the upper parts of the tree crowns. Estimates of populations were made in individual trees ranging in height from 13 to 76 feet. These were based on the average number of larvae per branch tip and the counted number of tips on each tree. The population ranged from fewer than 10,000 larvae in the smallest tree to 196,000 in one of the taller trees. Data were obtained on the development and migration of larvae, host-parasite relationships, and the behaviour of adults in relation to physical factors and migration. A long-range program of forest management has been outlined, with the object of reducing the amount of mature lodgepole pine and replacing it with other species such as Douglas fir and spruce. Such a stand would be more resistant to both the needle miner and bark beetle outbreaks.

Hemlock looper.—In British Columbia, studies of the deterioration of timber defoliated by the hemlock looper in 1946 were continued during 1949. It is evident that in 1949 the secondary insect population reached its peak, causing the highest rate of mortality among marginal trees since 1946. This applies to all species, although western hemlock was affected to the greatest extent, with Douglas fir, balsam fir, and Sitka spruce following in the order named. Most of the mortality has occurred among trees that had lost 95 per cent or more of their foliage, but some has occurred among those that had lost only 50 per cent.

The nearer the trees to large areas of killed timber, the higher the death rate. The study has included a wide survey of all secondary insects responsible for the attack, including wood borers and bark beetles and the natural control factors operating on them.

Ambrosia beetles.—A mill study of damage due to ambrosia beetles was initiated at the Victoria, B.C., laboratory in co-operation with the Forest Products Laboratory at Vancouver and with the British Columbia forest industry. Among the objects of this study are the appraisal of damage, the formulation of control measures, and the determination of a damage index that can be used in the field to secure advance information on mill losses.

Native elm bark beetle.—Studies on the biology and control of the native elm bark beetle, principal carrier of the Dutch elm disease in Canada, were continued. Various DDT spray formulations were investigated to determine their value as control agents. DDT emulsion sprays at concentrations of 5 pounds of DDT per 100 gallons of water remained lethal to the adult beetles from spring until late fall. At concentrations of 10 pounds to 100 gallons, the residue on the bark surface remained effective up to sixteen months. The investigations indicated that healthy trees may be protected in an affected area by spraying the diseased and bark-beetle brood trees. After the sprays had been applied in the spring and early summer of 1948 to diseased and bark-beetle brood trees in large elm plots, no new infection was recorded in late 1949. The investigation will be continued in 1950 to define more clearly the relationship between the spread of the disease and bark-beetle population densities, biological control factors, and the application of chemical control measures.

'Dieback' of birch.—The bronze birch borer is not responsible for the initiation of the 'dieback' of birch and multiplies only in trees weakened by other causes. The primary cause of the widespread dying of birch has not yet been determined, but the injury has been most severe in stands that were overmature or disturbed by careless cutting. In New Brunswick the remaining trees are now recovering, but the damage continues to increase in parts of Nova Scotia. In the Green River Watershed 70 per cent of the merchantable volume has died and another 15 per cent is severely injured.

Subterranean termites.—The infestation of subterranean termites in the City of Toronto continues to be severe. Extensive surveys showed that these pests are restricted to 7 or 8 distinct areas in southeastern Toronto and the neighbouring part of Scarborough township. The termites are well established and total eradication is an impossibility. Advice on methods of prevention and control is available to the public in the form of circulars obtainable from the Division of Entomology, Ottawa, or from the Department of Buildings, Toronto. In surveys in the southern counties of Ontario from the Niagara Peninsula to Lake Huron, no specimens were found.

Yellow-headed spruce sawfly.—In the parkland districts of Saskatchewan, injury by the yellow-headed spruce sawfly to spruce in farm shelter-belts was prevented by spraying the shelter-belts with benzene hexachloride (6 per cent gamma isomer), 50 per cent wettable powder, at 1 pound in 100 gallons of water, just when the adult sawflies were emerging from the ground. Satisfactory control of the larvae was obtained by spraying the trees with parathion, 25 per cent wettable powder, at one-half pound in 100 gallons of water. Parasitism of the yellow-headed spruce sawfly was found to be more important in farm shelter-belts than formerly supposed. It ranged from 30 to 40 per cent.

Blister beetles.—Excellent control of 4 species of blister beetles destructive to caragana field shelter belts was obtained with a spray of parathion, 25 per cent wettable powder, a 2 pounds per 100 gallons of water, and with a spray containing

1 pound of toxaphene per 100 gallons of water. As blister beetles have proved serious pests of caragana hedges during years of grass-hopper abundance, this information on effective control should be valuable to tree growers in the Prairie Provinces.

Systematic Entomology

Work has continued along the following major lines: (1) identification service on insects and other arthropods associated with economic problems of agriculture and forestry; (2) development of the Canadian National Collection, with research in special groups; (3) surveys of insects, particularly those of arctic and subarctic Canada, with special attention to the biting flies; and (4) investigations of insects associated with field crops in the Prairie Provinces, with attendant life-history studies and taxonomic analyses. Extensive projects completed involved a monograph of the fleas of Canada, and the chalcidoid section of a synoptic catalogue of nearctic Hymenoptera.

The greater portion of time has been devoted to the determination of material associated with the projects of the Biological Control Investigations Unit and the economic units of the Division of Entomology, and the Division of Plant Protection, as well as of a considerable number of specimens submitted by workers in provincial entomological services, and museums and universities. Co-operation has continued with officers in the other units of the Division in the solution of problems such as taxonomic studies of root maggots of vegetable crops, of beetles causing damage in forests and orchards, and biting flies. The taxonomic analysis of insects associated with the crop rotation project at Saskatoon has continued, with special reference to Hemiptera and the immature forms of several orders. Additions to staff have improved identification services in Hemiptera, particularly the leafhoppers (Cicadellidae); Trichoptera; Lepidoptera, particularly Geometridae and Pyralidae; Diptera, especially mosquitoes (Culicidae); Hymenoptera, particularly parasitic wasps of the family Braconidae; and Siphonaptera, or fleas.

Coleoptera.—In the Coleoptera, research has again been directed toward problems of nomenclature in the Chrysomelidae (leaf-feeding beetles). Studies were completed on the Canadian species of *Lyperopherus* (ground beetles), *Stethorus* (mite-feeding beetles), and the species confused with the bronze birch borer. A survey was made of the beetles of Newfoundland, about 10,000 specimens being collected, and many of these were studied and incorporated into the Collection. Studies were continued on European species of Coleoptera that have become established in Canada. Seven species new to North America were identified, and data on the distribution and habits were accumulated on 40 species previously discovered in Canada.

Lepidoptera.—In the Lepidoptera, 10,000 moths and butterflies, in addition to Northern Survey material, were incorporated into the Collection. A study of geographic variation in a group of the cutworm genus *Diarsia* was completed. A number of species of phalaenids (cutworms) were reared from the egg to the adult stage to establish familiarity with the immature forms. Progress was made on a study of the subfamily Heliothinae.

Diptera.—In the Diptera, emphasis was placed on the biting flies (Culicidae, Simuliidae, and Tabanidae); and a working key to the pupae of Canadian black flies has been prepared, and placed in the hands of field workers engaged in survey and control work in the North. Thirty-five named and 17 unnamed species of black flies are now recognized in the Canadian fauna. A study of tarsal claws aided in the segregation of several species of band-legged mosquitoes of the genus *Aedes*, the female adults formerly being inseparable. Two further species of root maggots were discovered, adding to the complex of species attacking cruciferous vegetable crops.

Hymenoptera.—In the Hymenoptera, much attention has been directed to study of parasites of root maggots, especially those of the carrot rust fly from England; parasites of European tortricids related to the economic nearctic budworms; parasites of orchard pests in Nova Scotia, notably of the eye-spotted bud moth; and parasites of forest insects in Canada. Re-arrangements of material and the preparation of working keys to various genera and species of the tribes Tryphonini, Pionini, Mesoleiini, and Euryproctini (Ichneumonidae) were completed. A study was completed on the species of *Phanerotoma* (Braconidae) in the Canadian National Collection, with the descriptions of 2 new species. Emphasis in the Chalcidoidea was laid upon species imported from Europe, and upon the parasites of the lodgepole needle miner. The available material of the genus *Harmolita* (jointworms) was classified to species.

Hemiptera.—A study of the Hemiptera, a major group containing many serious pests of field crops, orchards, and forests, including carriers of virus diseases of plants, was commenced. Re-arrangement of the Collection in accordance with modern classification was undertaken, and unidentified specimens were named and incorporated. Many species new to Canada were discovered, including some important crop pests. Revisions of the Canadian leafhoppers (Cicadellidae) of the tribe Balcluthini and of planthoppers (Fulgoroidea) of the family Cixiidae, with descriptions of species new to science, were completed. Revisions of genera of leafhoppers and planthoppers that include important forest and field crop pests are in progress.

Northern Survey.—In 1949 the Northern Survey involved 11 parties undertaking extensive studies on biting flies and other insects. Survey teams were located at Gander and Harmon Field, N'fld.; Port Harrison, Great Whale River, and Rupert House, Que.; Moose Factory, Ont.; Yellow Knife, Norman Wells, and Cornwallis Island, N.W.T.; and Dawson City, Y.T.; and a radio propagation mobile unit operated from The Pas to Churchill, Man. The Survey was made at the request of the Defense Research Board, Department of National Defense, and was part of a co-operative project among the Division of Entomology, the Division of Botany and Plant Pathology, and several Canadian universities. Two officers of the medical divisions of the United States Army and Navy took part in special phases of the work. Valuable data were obtained on the distribution and biology of arctic and hudsonian mosquitoes, black flies, and horse and deer flies. Radio-active isotopes were successfully used as an aid in tracing dispersal of mosquitoes. In addition, the parties collected approximately 100,000 insects representing most of the orders; these have been incorporated into the Canadian National Collection.

Stored Product Insect Investigations

Considerable insect infestation developed in U.S. grain stored in Canadian terminal elevators during 1949. This necessitated detailed examination of the stocks and implementing of control measures to ensure that Canadian grain stored in the same facilities would not become contaminated.

A new laboratory has been opened at Vancouver, B.C., to deal with the insect problems of grain storage, food manufacture and imported food materials.

The fumigation of elevator boots in flour mills with materials possessing a low vapour pressure yielded immediate control of flour beetles. Treating legs and boots simultaneously was more effective than treating boots alone, but there is a considerable migration into the boots with the moving stock, indicating the necessity of treatment at other points in the mill.

A small experimental set-up of mill machinery has been completed to permit the study of the biologies and activities of mill insects under practical mill conditions.

The search for a non-poisonous insecticide for use about food products resulted in extensive testing of piperonyl butoxide-pyrethrin mixture as a substitute for DDT. The new treatment proved much less effective than DDT when applied as a residual spray to warehouse surfaces.

Piperonyl butoxide-pyrethrin mixture has proved very effective as a treatment of fabric and paper bags for the storage of flour. Cotton sacks treated at 75 milligrams per square foot completely resisted entry for over 15 months.

The use of better sanitation measures and of vacuum cleaning equipment has greatly reduced the infestation of *Trogoderma versicolor* (Creutz.), in spray-type milk powder plants.

The infestation of the tobacco moth in warehouses in southwestern Ontario has been greatly reduced by the use of a water-suspension type of DDT spray.

Fundamental research concerning the haemocytes of the Mediterranean flour moth, *Ephestia kühniella* Zell., as possible sites of detoxification in the presence of certain fumigants was initiated during 1949. As an introduction to this investigation, the normal blood cell picture of the insect was determined in all stages of development.

Close contact has been maintained with the Board of Grain Commissioners on insect problems of stored grain. Assistance in insect problems has been rendered to those operating grain elevators, flour mills, warehouses, seed plants, and various types of food processing establishments.

Biological Control of Insects

The use of insect parasites, predators, and disease organisms was further explored as a means of reducing the losses from insect pests. Field and laboratory research were greatly facilitated by the increased activity of the laboratories in Quebec and British Columbia and the intensified study of certain insect diseases. Further equipment and personnel were provided for the research centre at Belleville, where the rearing of parasites and investigations on fundamental problems of biological control were continued. One hundred shipments of beneficial insects from many parts of Europe, South America, and the United States were received, and numerous species of parasites and predators were thus made available for study, propagation in the laboratory, and release in the field. The services of the Commonwealth Bureau of Biological Control were utilized in obtaining material from Europe. From foreign importations and laboratory propagation during the year, 51 species of parasites and predators, 532,895 individuals in all, were released in connection with the control of 20 major pest species in the 10 provinces.

Biological control of forest insect pests.—Continued efforts were made to effect control of the spruce and jack pine budworms in Eastern Canada and Manitoba. Several species of parasites from British Columbia were released in infested areas in Manitoba, Ontario, Quebec, New Brunswick, and Newfoundland. Colonies of parasites reared from closely allied insect species in continental Europe were liberated at selected points in Quebec and northern Ontario where studies on their establishment can be followed. Progress was made in the laboratory propagation of both native and introduced parasites. Two species attacking larvae of the budworm and 3 species attacking pupae were reared in the laboratory and released in the field. The use of an artificial medium consisting mainly of liver and fish made possible the large-scale production of the parasite *Pseudosarcophaga affinis* (Fall.) and gives promise of providing a means of propagating other species more economically in the the laboratory. Further, a diet composed wholly of chemicals was formulated which will adequately support growth and development. This provides a basis for further research on the biology and nutrition of parasitic insects and is the first known record of the propagation of a parasitic insect on a wholly synthetic diet.

Differentiation of various groups of closely related budworm parasites was made possible by the discovery of distinguishing characteristics in the chromosome structure; hitherto inseparable groups may now be distinguished and studies made on their relationship and importance in biological control.

Investigations showed further progress in the increase and spread of two imported parasites of the larch casebearer, *Agathis pumilus* (Ratz.) and *Chrysocharis laricinellae* (Ratz.). *A. pumilus* has spread 135 miles from the original liberation point near Millbridge in Hastings county, Ont. *C. laricinellae,* although well established in the same area, has not dispersed so rapidly. The two parasites have followed a definite pattern in their control of the larch casebearer. A very high parasitism is built up in the immediate vicinity of the initial liberation point. The parasites then disperse, causing high parasitism in a narrow ring, gradually moving farther away from the liberation point, and reducing host populations to extremely low levels. Both parasite species have been collected from this area and distributed in other infested areas of Eastern Canada.

Larch sawfly cocoons collected in 1948 in British Columbia were reared at Belleville for the recovery of the imported parasite *Mesoleius aulicus* (Grav.). Large colonies of this species and of a cocoon parasite, *Tripneptis klugii* (Ratz.), were released in the National parks in Manitoba and in Saskatchewan and Ontario. Releases of *Aptesis basizonia* (Grav.), a cocoon parasite of sawflies, were also made in the more heavily infested stands in Manitoba. Field studies on the role of introduced parasites in the control of the larch sawfly in Manitoba were carried out in co-operation with the Forest Insect Investigations Unit at the Whiteshell and Riding Mountain National parks. Parasitized cocoons were again collected during the autumn in British Columbia to provide parasites for release in 1950. Assistance will be provided United States entomologists by forwarding a portion of these parasites for release against the larch sawfly in Minnesota.

Six species of parasites were released for control of sawflies infesting spruce, balsam, and pine in various parts of Canada. Large numbers of the parasite *Drino (Prosturmia) bohemica* Mesnil were released against the European spruce sawfly in Newfoundland, Nova Scotia, Quebec, and Ontario. Three species of parasites destructive to eggs of sawflies in Europe were imported for study and release in Canada. Laboratory methods of propagation were developed and a considerable number were released in Ontario against the European pine sawfly, the jack pine sawfly, and the red-headed pine sawfly. Research was continued on the lethal temperature limits of sawfly parasites with particular reference to the influence of climatic conditions on their distribution in nature. Further studies were made of the temperature and humidity condition preferred by parasites and of improvement of laboratory propagation by selective breeding with a view to the application of genetic selection in the production of more effective strains of parasites.

A preliminary study was made in Europe on the biological control of the balsam woolly aphid. Shipments of predacious insects were received and studies were commenced on the biologies and habits of the more important species with a view to their colonization in New Brunswick during 1950.

In an attempt to establish control of the European pine shoot moth in southern Ontario, 6 shipments totalling about 21,000 individuals were obtained from Belgium. From this material 23 species of parasites were recovered, and a number of the more important species were released in the infested areas. A considerable stock of 2 parasite species was reared in the laboratory and these will be released in 1950.

A search was made in Europe and the United States for parasites of the lodgepole needle miner. Four shipments of infested pine needles were received

from California and Idaho and 8 from Switzerland. Two species of the United States parasites were released at Banff, Alta., and Marble Canyon, B.C., and 2 species of the European parasites were liberated in Kootenay National Park, B.C.

Biological control of field crop pests.—Investigations on parasites and disease organisms of grasshoppers were continued. The numbers of parasites in different localities and in different host species, although markedly dissimilar, resulted at times in very high grasshopper mortality. In one area 11 species of primary parasites were found. Further information was obtained on the biology and economic importance of 24 species of parasites of nymphal and adult grasshoppers. Parasites obtained from Argentina were released near Saskatoon, Sask. The well known fungous disease caused by *Empusa grylli* Fres. was present throughout Western Canada but appeared only locally and killed only a small number of grasshoppers. A large number of strains of bacteria were isolated from both living and dead grasshoppers from Eastern and Western Canada, but no important bacterial disease occurred among grasshoppers in field populations.

The parasite *Collyria calcitrator* (Grav.), introduced from Europe in 1940 to aid in the control of the European wheat stem sawfly, continued to show excellent establishment and spread in central Ontario. This parasite now appears to be an important factor in keeping the sawfly below an economic level.

The continued spread in southern Ontario of the European mantis indicates that this beneficial insect is now of considerable importance in controlling pasture and field crop insects in some areas. Climate and local topography have a marked effect on the population density of the mantis. Fewer and smaller egg masses are deposited in upland pastures, but their survival is higher than on lower ground subject to winter and spring flooding. In spite of the higher egg mortality, conditions in the lower areas are more favourable to establishment and growth, because of the variety and larger number of prey; and such lower areas, therefore, serve as reservoirs in maintaining the mantis population.

Studies have confirmed that the carrot rust fly is free from attack by parasites in Canada. Two parasites, *Dacnusa gracilis* (Nees) and *Loxotropa tritoma* Thoms., which attack the carrot rust fly in England, were imported during 1949 and released in the more heavily infested areas of Ontario. *D. gracilis* was also released in the Fraser Valley in British Columbia. Arrangements were made for the introduction of parasites of root maggots attacking cabbage and turnip, and 4 species of parasites were released in Ontario.

Further studies have been made in Eastern Canada on *Ascogaster quadridentata* Wesm., an introduced parasite of the pea moth. A substantial increase in the abundance of the parasite has been recorded in Prince Edward Island and the Gaspe Peninsula.

A search was made in Europe for parasites to control the cabbage seedpod weevil in British Columbia. Three species of parasites were found in Switzerland, and a number were imported for rearing and subsequent release against the weevil in the Fraser Valley. Further releases of European corn borer parasites introduced from Europe were made, 1 additional species being released in southern Ontario and 2 in New Brunswick.

In the chief areas of clover seed production in Ontario there are no parasites of the currently destructive European clover seed weevil. Efforts are being made to find effective biological agents of control in other countries with a view to their colonization in the infested areas of Canada.

An imported parasite of the holly leaf miner, *Cyrtogaster vulgaris* Wlk., released in British Columbia in 1936, was recovered in 1949 for the first time.

Biological control of fruit and greenhouse pests.—Investigations were made on the tolerance of *Macrocentrus ancylivorus* Rohw., a parasite of the oriental

fruit moth, to insecticide residues and on the possibility of breeding insecticide-resistant strains of the parasite in the laboratory. By means of a new method involving uniform and precisely defined crystalline films deposited on standard test surfaces, it was found that this parasite can survive exposures of short duration to insecticide residues of normal concentration. Males are more susceptible than females to the lethal effects of DDT residues, but no mutagenic action was caused by either DDT or benzene hexachloride. It appears possible by simple selection to develop strains of the parasite resistant to the lethal effects of spray residues.

Parasitized larvae of the codling moth were obtained from Belgium, Switzerland, and Spain. Of the 8 species of parasites reared from the imported material, 1 species new to Canada, *Pimpla turionellae* (L.), was present in sufficient numbers for release in Nova Scotia.

Numerous shipments totalling over 400,000 individuals of *Encarsia formosa* Gahan, a parasite of the greenhouse whitefly, were forwarded to greenhouse operators in nearly all provinces of Canada as a means of reducing the cost of producing crops under glass. Studies were also carried out to determine the possibility of introducing other species of parasites having greater searching ability with a view to holding greenhouse pests at much lower population levels. Stocks of 2 additional species are being obtained from the United States.

Parasites and predators of biting flies.—A study of the natural control of biting flies in Canada was initiated, work in 1949 consisting largely of a survey near Churchill, Man., through facilities provided by the Defence Research Board. Insects found to be predacious upon *Aedes* spp. of mosquitoes included adults of several species of dytiscid beetles, larvae of chaoborine mosquitoes, dragonflies, and aquatic Hemiptera. Two species of the common stickleback fish destroy numerous mosquito larvae, particularly in permanent pools. A round worm and a chalcid parasite, *Diglochis occidentalis* (Ashm.), were important in the destruction of larvae and pupae of moose and deer flies (tabanids). Black flies were preyed upon largely by mites, round worms, and small fish. These agents play an important part, but are not wholly adequate to control the pests in northern Manitoba.

Livestock Insect Investigations

The two laboratories, one at Kamloops, B.C., and the other at Lethbridge, Alta., engaged in studies of insects and ticks affecting livestock devoted less time to biological studies and more to the study of some of the newer organic insecticides in 1949-50. Because DDT, which had given great promise in the control of many of the pests of livestock, was found to be absorbed by animals and stored in the fatty tisues, its use has been greatly restricted.

Rocky Mountain wood tick.—At the Kamloops, B.C., laboratory, where studies on the Rocky Mountain wood tick have constituted a major project for several years, cattle going onto tick-infested spring ranges were sprayed with benzene hexachloride and remained practically free of ticks throughout the tick season. The few ticks found on sprayed animals apparently did not feed, and no cases of paralysis were reported. None of the cattle showed any ill effects from the sprays, nor was there any sign of taint in the meat. A spray of benzene hexachloride and derris proved very effective in controlling ticks and warbles at the same time, and the cattle remained free of ticks for over 2 weeks. This procedure will enable cattlemen to spray their cattle once for both warbles and ticks before turning them out on the range.

Winter tick.—Studies on the winter tick at Kamloops, B.C., throughout the winter showed that though the ticks remained up on grass and shrubs at

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the lowest sub-zero temperatures ever recorded at Kamloops, they were inactive and were readily dislodged from the grass or the shrubs but resumed activity as the temperature rose above zero. Benzene hexachloride dust was found to be the most satisfactory treatment for the winter tick on horses.

Warble flies.—Experiments at Lethbridge, Alta., showed that grubs dropping from the cattle may survive temperatures below zero except during a short period just after pupation. During this period, they do not survive temperatures below 5°F. Larvae dropped in the field survived temperatures as low as −20°F., 43 per cent of such insects emerging as adult flies.

Sheeptick (Sheep ked).—Experiments with different insecticides at varying rates and spray pressures for the control of the sheeptick were conducted at Lethbridge, Alta. Each of the insecticides used gave effective control for at least 33 days with one treatment. Chlordane as a 0·25 per cent spray destroyed the greatest number of the insects and a 0·5 per cent DDT spray was almost as effective. Sprays applied at 160 pounds pressure were more effective than those at 500 pounds pressure.

Horn fly.—At Lethbridge, Alta., investigations were begun on the horn fly, one of the most widespread, persistent, and irritating pests of cattle in Canada. A 0·5 per cent DDT spray kept the cattle reasonably fly-free for 2 to 4 weeks. The fly-free cattle made substantially greater gains in weight than the untreated checks and approached the winter in much better condition. Cattle on the open range were treated by setting up a wing fence with an overhead spray boom at a small opening and driving the cattle through the spray.

Household and Medical Entomology

The biology and control studies of biting flies in northern Canada, carried out on behalf of the Defence Research Board at Churchill in 1947 and 1948, were continued in that area in 1949, but were expanded to include investigations at Goose Bay, Labrador, and in northern British Columbia and the Yukon from headquarters at Whitehorse, Y.T. Results of these studies include new knowledge on the occurrence, distribution, and bionomics of the various species, and developments in materials, methods, and equipment effective in the chemical control of pest species.

Mosquitoes.—Twelve species of culicine mosquitoes, including 10 of *Aedes* and 2 of *Culiseta*, and 4 species of Chaoborinae have been under investigation at Churchill, Man.

A large number of mosquitoes were reared and measurements made of proboscis length and wing length of all specimens of this group positively identified by association with the last larval skin. The ratio of proboscis length to wing length was found to have value in identifying the majority of females of certain of the common dark-legged species of *Aedes*.

Rearing of mosquitoes at field study stations in the Churchill area confirmed that *Aedes communis* (DeG.) is a true forest species, and *A. punctor* (Kby.) resembles it in this respect. *A. nigripes* (Zett.) is the species most clearly associated with tundra areas, and *A. nearcticus* Dyar shows a similar tendency. In every species the first males emerged from 1 to 5 days earlier than the first females, and the last females from 1 to 15 days later than the last males. Data from field cages suggest that the sex ratio for these species is initially about 1:1.

A survey indicated that peaks of populations of adults on the wing at Churchill fell on June 30, July 9, and July 15. The first of these peaks represented mainly the tundra black-legged species, *Aedes nearcticus* and *A. nigripes*,

and the second represented the residue of this population plus the peak population of the woodland black-legged species, *A. punctor* and *A. communis*. The third peak occurred when *A. excrucians* (Wlk.), *A. campestris* D. & K., and *A. flavescens* (Müll.), the banded-legged species, were added to the dwindling population of the black-legged species. The peaks of attack fell on July 7, 15, and 24.

The effects of weather factors were evaluated from data taken daily at various field stations. Rather high biting rates were recorded even at temperatures below 45°F. Between temperatures of 50 and 80°F. there was no regular variation in mosquito attack. The intensity of attack immediately prior to thunderstorms can be explained as the combined effect of 3 important factors, namely: low wind speed, cloudiness, and high humidity. The influence of wind speed, both on flying and on biting activity, appears to be primarily a mechanical one: because controlled flight in the wind is difficult, biting is also difficult.

Mating of *Aedes* mosquitoes appears to take place shortly after emergence. The typical mosquito mating swarm has now been observed for most of the species commonly abundant at Churchill.

In addition to seeking blood, the females of all the Churchill species of *Aedes* apparently feed on nectar. Pollinia of a common woodland orchid, *Habenaria obtusata* (Pursh) Richardson, were found attached to the eyes of specimens collected in 1947, 1948, and 1949, and data indicated that 28 to 74 per cent of the mosquitoes had fed on this orchid. In addition they were observed resting and apparently feeding on the flowers of several other abundant plant species.

At Goose Bay, Labrador, in 1949, 15 species of mosquitoes representing 5 genera were identified, and a number of them reared. They included 10 species of *Aedes*, 2 of *Culiseta*, and 1 each of *Culex*, *Wyeomyia*, and *Anopheles*. In the Yukon and northern British Columbia, 22 species were reared or collected, including 17 of *Aedes*, 4 of *Culiseta*, and 1 of *Culex*.

Data collected weekly from June 23 to August 20 at 16 study stations at Goose Bay showed that mosquito abundance and activity increased in a steep gradient from open to transition to forested areas. These data indicated the practical value of removing forest growth from the immediate vicinity of human habitations in securing relief from mosquitoes for communities in regions where forest species of mosquitoes predominate.

Aerial spraying.—A satisfactory formulation and dosage of DDT having been established in 1947 and 1948, the effectiveness of aerial spraying against mosquitoes in limited areas under a variety of conditions was tested in 1949 with the co-operation of the R.C.A.F. and the Defence Research Board. At R.C.A.F. stations at Whitehorse and Watson Lake, Y.T., Fort Nelson and Fort St. John, B.C., and Goose Bay, Labrador, 4 per cent DDT in fuel oil solution was applied by R.C.A.F. Dakota (C-47) aircraft. A total area of 68·1 square miles in the five localities was treated at a dosage of approximately one-quarter of a pound of DDT in three-quarters of a gallon of spray per acre against predominantly forest species of *Aedes* mosquitoes; 43·1 square miles were sprayed against the larvae and 25 square miles against the adults. An unusually even deposit of DDT was obtained when cross-wind spraying was practised at such heights that the height-wind product was 1700 feet-miles per hour; under stable atmospheric conditions a height-wind product of 800 and calm air conditions gave very uneven deposit. Control of larvae ranged from 83 to 99 per cent, the average for the five areas being 91 per cent. Where pupae were present, many survived. The larvicide applications resulted in a significant reduction of adult mosquito populations that persisted for about two weeks to two months from the date of spraying. The effect of the reduction was most marked in the cleared areas of the camps and aerodromes.

Applications against adults at Fort Nelson, B.C., Watson Lake, Y.T., and Ottawa, Ont., caused an immediate reduction in numbers of approximately 84 per cent, and an average reduction during the succeeding three weeks of approximately 65 per cent. At Goose Bay moderate numbers of mosquitoes infesting the air base three weeks after the larvicide application were largely eliminated by spraying an area of two square miles, no further significant infestations developing.

Black flies.—More than 16 species of black flies have been recorded in the Churchill area, several of them new to science. The dominant pest species in the area, *Simulium venustum* Say, was found to pass the winter in the egg stage and produce two generations during the summer season. The mid-point of emergence of the first generation was mid-July; that of the second generation, mid-August. Critical light values for black-fly flight and feeding were as follows:—cessation of flying and biting: tundra, 900 lumens per square foot; forest, 500; resumption of flying: tundra, 1800; forest, 1250; resumption of biting: tundra, 1800; forest, 1750. When the wind velocity approximates 10 miles per hour or more, black flies take refuge in low-lying vegetation.

Twelve species of black flies, the majority of which are newly recorded for the region, were found during a preliminary study in the Goose Bay, Labrador, area, embracing 16 rivers and streams and stream systems. Collections of adults revealed three species to be dominant. The first adults appeared in mid-June, but heavy infestations did not develop until the latter part of July and continued through August.

Studies at Saskatoon showed that the eggs of *Simulium arcticum* Mall. are laid singly on the river surface in summer and sink to the river bed; here they eventually become buried in the sand and overwinter, hatching the following spring. The eggs were found during the winter months in concentrations of 24 and 44 per square foot in the sand of the bottom of the South Saskatchewan River.

Control.—At Churchill in 1947 an effective formulation and dosage was developed for the control of immature stages of black flies, namely, DDT in fuel oil solution, at a concentration of 0·1 parts per million maintained for 15 minutes at the point of application. The effectiveness of this treatment was successfully demonstrated in 1948 and 1949 on a large scale in the South Saskatchewan River and in 1948 in the Lewes River in the Yukon, by further tests in 1949 at Churchill and Whitehorse, and by observations in 1949 in streams flowing through large areas sprayed experimentally in mosquito control. Various formulations of other chemicals were tested, including methoxychlor, toxaphene, chlordane, gamma benzene hexachloride, dieldrin, aldrin, 1,2,4-trichlorobenzene, a pyrethrum-piperonyl butoxide mixture, and parathion. No other compound was found to be so satisfactory as DDT. In field experiments none of the materials proved effective against eggs or pupae of black flies.

In 1947-49 the treatment of streams with 5 or 10 per cent DDT in fuel oil solution at the recommended dosage caused no harm to fish. However, experiments in the South Saskatchewan River in 1949 demonstrated that a 30 per cent DDT concentrate in methylated naphthalenes applied without dilution is harmful. Dosages of 0·39 parts per million of DDT for 24 minutes, and of 0·113 parts per million for 16 minutes each killed numerous fish. Unlike the fuel oil or kerosene solutions of DDT, this preparation is heavier than water and the fish were apparently poisoned by swallowing globules of the DDT concentrate.

The aerial sprays applied against adult mosquitoes were relatively ineffective in reducing infestations of adult black flies.

Tabanids.—Three additional species of tabanids reared or collected in 1949 have brought the total number of species recorded in the Churchill area to 17,

including 10 of *Hybomitra*, 5 of *Chrysops*, and 2 of *Atylotus*. Larvae and pupae were found in all types of moist habitat in or near wooded areas. The species studied were found to pass the winter in the larval stage either at the bottom of small pools or 3 to 4 inches below the frozen moss surface. Data indicate that the life-cycle of certain species occupies two years and perhaps longer. Larvae of the tipulid *Prionocera dimidiata* (Lw.) were found to be important predators of larvae of *Chrysops* spp. The chalcid parasite *Diglochis occidentalis* (Ashm.) was reared from pupae of both *Hybomitra* spp. and *Chrysops* spp., which had been parasitized in the larval stage. Tabanid adults are active on warm, clear days and bite most readily under conditions of high relative humidity and attack humans especially when the skin is wet. Peak activity occurred when the temperature was 68° to 73°F., the saturation deficiency 9 to 12 millimetres of mercury, and the light intensity 6000 to 7500 lumens per square foot. Activity was greatest between 8.30 and 11.30 a.m. and fell off gradually in the afternoon. The presence of pollen on female tabanids of nearly all species captured indicates that they feed on flowers soon after emerging. When attacking man, the abundant, large species *Hybomitra affinis* (Kby.) was found to require about 4 minutes to become completely engorged, more than doubling its own weight in the process.

In 1949, 18 species of tabanids were taken at Goose Bay, Labrador, 2 being new to science. They include 11 species of *Hybomitra*, 1 of *Haematopota*, and 7 of *Chrysops*. Specimens taken in the Yukon and northern British Columbia include 12 of *Hybomitra* and 4 of *Chrysops*.

Aerosol generators.—In 1949 a study was commenced of the value of aerosol generators in controlling adult mosquitoes and black flies in localized areas. Tests at Whitehorse, Y.T., indicated that these machines have definite value when used properly under suitable conditions. Their chief disadvantage appears to be the narrow limit of meteorological conditions on which their use depends; a second is the need of roads to serve as base lines and to allow the operator to take advantage of prevailing winds.

Resistance of the house fly to DDT.—After being reared under standard conditions for several generations, 11 cultures of the house fly, *Musca domestica* L., originating from flies or pupae collected in several areas of Ontario and Quebec where resistance to DDT had been reported were submitted to a limited number of mortality tests. With one exception the flies from these cultures showed lower mortality rates than the standard laboratory culture, indicating a greater degree of resistance to the insecticide. However, no definite conclusions can be drawn regarding the presence of DDT-resistant flies in nature in Canada until a much larger number of tests have been carried out.

The Canadian Insect Pest Survey

Systematic collection of information on the occurrence, distribution, and economic importance of insect pests in Canada was continued in 1949. Data obtained were used in supplementing the Canadian Insect Pest Record, and in compiling Volume 27 of the *Canadian Insect Pest Review*, consisting of nine numbers and an index. One number was made up of a list of the parasites liberated throughout Canada during 1948, and one was a summary of insect conditions across Canada during the season. Several maps illustrating the distribution of insects of economic importance were incorporated into the *Review*. A survey indicated that the Canadian Insect Pest Survey is still far from adequate in the extent of its coverage of the agricultural areas of Canada. A summary of the more important insect infestations and occurrences of the year was prepared for publication in the Annual Report of the Entomological Society of Ontario.

DIVISION OF PLANT PROTECTION

This Division is responsible primarily for the administration of the Destructive Insect and Pest Act and the regulations thereunder. The Act was passed in 1910 and, to conform with government policy, the regulations under the Act were consolidated late in the previous fiscal year and were passed by Order in Council P.C. 2057 April 26, 1949, effective from April 1, 1949. At the time of the consolidation, an opportunity was afforded to revise a number of the existing regulations. Prior to the consolidation, twenty Foreign and ten Domestic regulations and one Export regulation were in effect.

The consolidation, known as the Destructive Insect and Pest Regulations, contains eight Parts as follows:

Part I.— General. (Interpretation and Powers of Inspectors).
Part II.— Admission of Plants into Canada.
Part III.— Importation of Insects, Pests or Diseases for Scientific or Educational Purposes.
Part IV.— The Movement of Plants within Canada.
Part V.— Exports. (Apples and Potatoes).
Part VI.— The Production and Sale of Certified Seed Potatoes.
Part VII.— The Production and Sale of Narcissus, Tulip, Iris and Hyacinth Bulbs Grown in the Province of British Columbia.
Part VIII.—Destructive Insect and Pest Act Advisory Board.

The procedure governing the importation of nursery stock, which includes plants or portions of plants for propagation, except flower, vegetable and field crop seeds, onion sets, garlic bulbs, mushroom spawn and seed potatoes, is briefly as follows:

1. A permit, procured from Ottawa, must be presented to Customs by importers when obtaining release of consignments.
2. All shipments to Canada must be accompanied by a certificate of inspection, issued by an authorized inspector in the country of origin declaring the contents to be apparently free from insect pests and plant diseases.
3. All importations are subject to reinspection in Canada, and to treatment or destruction, if necessary.
4. Interceptions of insects and diseases not readily identifiable by the inspection staff are referred to specialists in the Divisions of Entomology, and Botany and Plant Pathology.
5. All importations must be routed through one of the established ports of importation in Canada.

Plant Inspection staffs are maintained at the following points: St. John's, Newfoundland; Halifax, N.S.; Saint John, N.B.; Quebec and Montreal, Que.; Ottawa, Toronto, Niagara Falls, London, and Windsor, Ont.; Winnipeg, Man.; Estevan, Sask.; Lethbridge, Alta.; Vancouver and Victoria, B.C.

The certification of narcissus, tulip, hyacinth, and iris bulbs was started in British Columbia in 1948 and was continued during 1949.

The certification of seed potatoes was started in the Maritime Provinces in 1915. Since that time the standards have been raised steadily and the work extended to every province in the Dominion except Newfoundland. In 1938, this service became the responsibility of this Division and includes:

1. The establishment of standards governing production.
2. The supervision of production and shipment by inspection in the field, in storage, and at shipping point.
3. The development and supervision of tuber indexing and tuber units to improve and multiply foundation stock.
4. The issuance of official tags conforming to Canadian Certified seed potato standards.
5. Advice to growers on modern methods of seed potato production.

Certified Seed Potato Inspection staffs are stationed at Charlottetown, P.E.I.; Kentville, N.S.; Fredericton, N.B.; Ste. Anne de la Pocatiere, Que.; Ottawa, London, Guelph, Barrie, Ont.; Winnipeg, Man.; Estevan, Sask.; Edmonton, Alta.; Vancouver and Victoria, B.C.

Plant Inspection

The activities connected with Plant Inspection during the year ended March 31, 1950, are summarized as follows:

Imports of Plants.—There were 32,850,202 bulbs and 25,548,906 plants, or a grand total of 58,399,108 plant units valued at $2,587,478, imported from 33 different countries in 85,604 containers, under 10,638 standard and 654 emergency permits requiring 11,292 inspections, of which 3,988 dealt with parcel post importations involving 487,604 plants, bulbs, etc. Two hundred and ninety-nine importations of plants, totalling 29,570 units, were refused entry due to infractions of regulations under the Destructive Insect and Pest Act.

Inspection of Passengers' Baggage.—This activity applies mainly to ocean ports, where a total of 2,818 passenger and freight ships was attended. Six trains and twenty-eight automobiles were also attended. As a result, 177 passengers were found to have 4,178 plants and 314 pounds of plant products in their possession. One of the plants and 69 pounds of potatoes were refused entry under the regulations, and 194 pounds of fruit for lack of proper certification. The inspection staff works very closely with the Customs officers in carrying out these duties. At Windsor and Niagara Falls similar co-operation is provided to Customs officers and during the year 288 shipments of nursery stock and 19 of plant products were refused entry. These included 1,175 plants and 135 ears of green corn. At border points, where an inspector of the Division of Plant Protection is not available, the Destructive Insect and Pest regulations are administered by Customs officers. Plants being imported at such points, which are not prohibited by regulation, may be diverted through an authorized port of importation for inspection if the owner so desires.

Due to the heavy tourist traffic, Customs authorities requested that an inspector be stationed at the following border points to administer Regulations of the Department during the busy season: Sarnia, Ont.; and Pacific Highway, B.C., and a third inspector visited Ivy Lea, Ont., at intervals. As a result, 195 motorists were found to have 360 plants and 17,133 pounds of fruit in their possession. Three plants were refused entry under the regulations, and 563 pounds of fruit for lack of certification.

Introduction of Live Insects, etc.—During the year, 153 permits were issued under Part III of the Destructive Insect and Pest Regulations covering the importation for investigational and experimental purposes of various stages of insects, insect parasites, bacterial or fungous cultures, and plant diseases.

Imports of Plant Products.—There were 1,627 inspections of plant products from thirty-eight countries involving 91,838,310 pounds valued at $12,975,552. In 62 instances shipments were refused entry. These involved 900 potato eyes, 189 pounds of potatoes, 932 pounds of fruit, 135 ears of corn, 3 pounds of chestnuts and 5 pounds of cherry seed.

Export of Plants and Plant Products.—Nursery stock was inspected and certified for export to thirty-two countries, totalling 908,481 plants, 4,442,028 bulbs, corms and cormels; 6,002 pounds of tree and miscellaneous seed and two square yards of sod.

Plant products certified as a requirement of the importing country were exported to thirty-one countries and consisted of: 14,278,090 pounds of table stock potatoes, 10,000 pounds of flour, 45,900 pounds of minute oats, 196,217,040 pounds of wheat, 4,079,581 pounds of malt, 67,000 pounds of frozen blueberries, 10,000 pounds of bulk corn seed, 220 pounds of seed corn on the cob, 10 pounds of grass seed, 84,000 pounds of alfalfa seed, 100 pounds of clover seed, 1,360 pounds of flower seed, 120 pounds of wheat seed, one pound of tobacco seed, 32 pounds of sunflower seed, 38,760 pounds of vegetable seed, and 53,476 Christmas trees.

Interceptions.—The number of interceptions of insects and diseases taken on imported plants and plant products was 1,193. An interception of Fusarium basal-rot of amaryllis from California was of particular interest because of the few reports of infection on the host. Among the more important entomological interceptions were the following: adults and larvae of the European elm bark beetle on elm logs from Missouri, root knot nematodes from New York, the ring legged earwig from two points in the United States, larvae of the European corn borer in shelled corn from mid-western United States, shipped to British Columbia, a cocoon of the gold tail moth from the Netherlands, and the durra stem borer in broom corn from Italy.

Protection of Imported Food Products.—The inspection service continued to check carefully a large range of edible plant products. Importations from various countries of the world have been found infested with insects, and frequently fumigation or cold storage treatment has been required.

Bulb Certification, British Columbia.—At the request of the British Columbia Bulb Growers' Federation, a regulation was passed under the Destructive Insect and Pest Act in 1948 providing authority for inspection and certification of tulip, narcissus, iris and hyacinth bulbs. The bulb growing industry is concentrated on Vancouver Island and in the lower Fraser Valley. This work, started in 1948 and continued during 1949, is conducted from the Vancouver office of this Division.

Stored Products Inspections and Investigations.—Efforts were continued to safeguard food products from serious insect damage and consequent loss through the inspection of ships carrying grain and cereal products overseas. During the past fiscal year, 1,381 vessels were examined at seaboard ports and 255 of these required treatment by fumigation or cleaning; 107 were also examined at the Lakehead previous to taking on cargoes of grain for winter storage, and 22 required cleaning.

Montreal Fumigation and Research Laboratory.—In experiments conducted within the fumigation vault, it was shown that complete control of fully exposed granary weevils, *(Sitophilus granarius* L.) could be obtained. Experiments were also carried out on the possible corrosion of ship hulls as a result of methyl bromide fumigation. It is known that methyl bromide used as a fumigant can,

under certain circumstances, be corrosive to metals. Pieces of steel of the type and thickness employed in ship construction were obtained from a Montreal shipyard and cut into small pieces and specially prepared by the Division of Metallurgy, Department of Mines and Technical Surveys, Ottawa. Individual pieces will be exposed on board ships actually undergoing fumigation, and analysed for corrosive and insecticidal effects by the Division of Metallurgy.

During the month of November, the DDT Project was transferred in its entirety from this laboratory to the Science Service Building, Ottawa. This project, designed to test the residual effect of DDT on house flies on various surfaces, has been conducted for some time at this laboratory in co-operation with the Division of Entomology. A series of experiments was also carried out in connection with tobacco fumigants as a result of an outbreak of the cigarette beetle, *Lasioderma serricorne* (F) in tobacco kept in an air-conditioned storage. This work is continuing and results will be published later.

Field Projects

The main field projects carried on in 1949 with the object of determining the distribution and control of destructive insect pests and plant diseases were as follows:

Apple Maggot.—This insect is a native of North America and occurs in all fruit growing areas of Ontario, Quebec and the Maritime Provinces. It is not known to be established in Europe and on this account special precautionary measures have been undertaken each year by co-operating government agencies to safeguard and maintain the apple export trade. This Division co-operated in Nova Scotia with provincial authorities in the enforcement of control measures and assisted in the pre-harvest inspection of the fruit. The Division also assisted with the pre-harvest inspection of the fruit in certain orchards in New Brunswick, Quebec and Ontario, the owners of which had followed the control practices as stipulated in Part V (Export) of the Destructive Insect and Pest Regulations. By special arrangement with the British Ministry of Food, fairly large quantities of British Columbia and Nova Scotia apples were shipped to Great Britain from the 1949 crop.

Dutch Elm Disease.—This destructive disease of elm, first described in Holland in 1919, and discovered in the United States in 1930, was found in the province of Quebec in 1944.

The importation of elms has been prohibited from Europe since 1928 and from all countries since 1934. Since the discovery of the disease in Canada, the movement of elms and elm products from the infected areas has been controlled by regulation under the Destructive Insect and Pest Act. Surveys have been conducted annually by this Division, with provincial agencies co-operating in Quebec and Ontario, and in 1948 the disease was found for the first time in eastern Ontario. Since the disease was discovered in 1944, infected elms have been found in 41 counties in Quebec and 6 in Ontario. The Division of Plant Protection assumed the responsibility of supervising the removal of infected trees following the 1945 survey, and this policy has been continued. So far it has been possible to have trees removed by property owners, public utility companies, and the municipalities concerned, thus relieving the Federal and Provincial Departments of the expense. All infected trees located from 1944 through 1948 were removed by the end of May 1949, except a number located in a wood-lot in Richelieu County where it was impracticable to have the work performed. During the 1949 survey season, 695 infected trees were located in Quebec and, at the end of March, 1950, the number of trees cut was 518, with the expectation that the balance would be cut by the end of May. There were no infected trees located in Ontario during the 1949 survey.

Japanese Beetle.—This insect, a native of Japan, was first discovered on this continent in 1916 in the State of New Jersey. Since 1927, special precautions have been taken by this Division to prevent its introduction and establishment in Canada, but, in spite of all efforts, the first established infestation was discovered at Niagara Falls in 1940, and the second at Windsor, Ont., in 1941. Trapping has been carried on at various points throughout Eastern Canada since 1935. The Ontario Department of Agriculture has assisted with trapping operations by providing trap attendants each year, and the Nova Scotia Department of Agriculture has co-operated in a similar manner. From 1939 to 1949 inclusive, 4,771 beetles have been captured in traps and collected by scouting in Ontario, Quebec, and Nova Scotia. From 1941 to 1946 inclusive, 284 acres of soil were treated with arsenate of lead at several points in Ontario, and 4·5 acres at Halifax, N.S. The amount of arsenate of lead required to treat this acreage was 72·5 tons. In the spring of 1949, 37 acres of soil at several points in Ontario were treated with DDT at the rate of 25 pounds actual DDT per acre. This was the first time this insecticide was used for Japanese beetle control in Canada.

Oriental Fruit Moth.—This insect, a native of Japan, has been known to occur in Eastern North America for over thirty years where it has caused enormous damage to peaches and other soft fruits. During the last few years, it has spread to the Pacific Coast states and a few specimens were trapped in Washington in 1945. Fruit growers organizations and government agencies in British Columbia were greatly concerned about possible spread into that province and it was decided to carry on surveys in the preach growing areas. The United States Department of Agriculture co-operated with this Division by furnishing 400 specially designed traps and certain bait materials. These traps have been placed in peach orchards in southern British Columbia and examined regularly by officers of this Division during an eight-week period in midsummer in 1946, 1947, 1948 and 1949, but no specimens of the insect have been captured. Due to the discovery of an established infestation of this pest in Washington in 1948 it is proposed to conduct the survey in British Columbia again this year.

Grader Inspection of Fruit, British Columbia.—This work has been carried on from 1944 to 1949 inclusive in the packing houses in the southern half of the Okanagan Valley under the supervision of this Division. The B.C. Department of Agriculture and B.C. Tree Fruits, Ltd., have co-operated by supplying funds to cover a portion of the wages paid to the inspectors. The object of the survey is to locate infestations of the San Jose and European fruit scales in order that no fruit from infested orchards would be offered for export to countries demanding a certificate of freedom from scale insects. Results of the annual surveys have been made available to the co-operating agencies with recommendations that efforts be made to control the infestations. The 1949 survey indicated good progress had been made in several areas.

Nursery Inspection.—As a check on imported plants under field conditions and to locate outbreaks of insects or diseases, a program of nursery inspection is carried out during the summer months. In 1949, 112 nurseries were inspected in Ontario, Manitoba, Saskatchewan and British Columbia. At Islington, Ont., a skipper, *Adophoea lineola,* was found, the first one to be taken since 1914, and at Windsor, a scale, *Carulaspis visci,* was located.

Seed Potato Certification

The total acreage of potatoes entered for certification throughout Canada in 1949 amounted to over 72,000, representing an increase of approximately 2,700 acres. This is the largest acreage ever entered. Slightly over 89 per cent

of the acreage entered passed field inspection in the three classes. Over $9\frac{1}{4}$ million bushels of Foundation and Foundation A seed were produced out of a total of $18\frac{3}{4}$ million bushels which passed in the three classes. This total production is over 6 million bushels more than was produced in 1948 and is the highest on record.

Tuber indexing was continued in greenhouses at several points to aid growers in the selection of disease-free seed for tuber unit planting.

In 1949, 8,980 growers entered for inspection 15,476 fields, comprising 72,706 acres, of which 65,051 acres passed. This is the highest on record. The acreage passed of the main varieties were:—Katahdin, 24,507; Green Mountain, 14,475; Irish Cobbler, 10,889; Sebago, 9,889. This shows an increase in all the varieties except Irish Cobbler which decreased slightly from the previous year.

Shipments.—Shipments from the 1948 crop totalled 9,695,413 bushels, of which 7,655,315 bushels were exported and 2,040,098 were sold in Canadian markets. The principal importing countries were:—United States, 6,682,635 bushels; Cuba, 354,374; Uruguay, 263,123; Venezuela, 126,549; Argentina, 86,089; South Africa, 51,919; British West Indies, 33,965; Dominican Republic, 13,670; Israel, 12,821. The main exporting provinces were Prince Edward Island and New Brunswick with 3,472,880 and 4,039,858 bushels respectively.

Export shipments from the 1949 crop to March 31, 1950, totalled 5,409,549 bushels, and domestic shipments were approximately 200,000 bushels. The principal foreign markets for the 1949 crop were:—United States, 4,535,795 bushels; Cuba, 392,214; Uruguay, 283,844; Venezuela, 96,090; Palestine, 42,616; British West Indies, 29,137; Dominican Republic, 14,088. The main exporting provinces were Prince Edward Island and New Brunswick with 3,338,959 and 1,983,730 bushels respectively.

Foundation Seed.—The production of Foundation seed showed a large increase in 1949 over that produced in 1948. In 1949 the crop from 6,458 acres produced 1,629,677 bushels compared with 4,482 acres yielding 919,450 bushels in 1948.

Foundation A Seed.—The production of Foundation A was greatly increased in 1949 over the production in 1948. In 1949, 30,304 acres produced 7,677,247 bushels compared with 22,196 acres yielding 4,480,800 bushels in 1948.

Certified Seed.—The production of certified seed in 1949 showed an increase of approximately 8,000 acres, producing over two million bushels more than in 1948.

Production.—Total production of the graded stock in 1949 has been estimated at $18\frac{3}{4}$ million bushels, of which 1,629,677 bushels were eligible for Foundation tags, 7,677,247 bushels for Foundation A tags, and 9,494,112 bushels for Certified tags.

Tuber Indexing.—Tuber indexing was carried on during the winter in Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Manitoba, and Alberta. A total of 61,157 tubers were indexed in the above mentioned provinces during the winter of 1949-50. Over 53,000 were returned to the growers for tuber unit planting.

The Potato Rot Nematode.—(Ditylenchus destructor Thorne)—This pest was first found in Canada in Queens County, Prince Edward Island, in 1945 by inspectors of this Division. Since that time, the three areas where the nematode has been discovered (York, Uigg, and Bideford) have been under quarantine,

which quarantine has been enforced largely by inspectors of this Division. In these areas, certified seed potatoes cannot be produced, and table stock potatoes produced only in fields where nematodes have not been found. However, all table potatoes produced in these areas must be held until November 15 of each year and inspected for nematodes before they can be moved off the farm. In 1949 this pest was found in four fields in the quarantine area.

International Plant Legislation

Regulations maintained by foreign countries, covering the importation of plants and plant products, are studied and summarized as affecting exports of such material from Canada. Copies of the summaries prepared are distributed to Divisional staffs throughout the country for their information and guidance in certifying export shipments of these commodities.

Because of the great increase in air traffic, the air lines operating in North America took action in 1947 to establish a Canada-United States Air Facilitation Committee. In addition to officials of air transport companies, the Committee is composed of representatives of Customs, Immigration, Post Office, Health and Welfare, and Agriculture. The Committee held one formal meeting during the year in Hamilton, Bermuda. The officer of the Division of Plant Protection appointed by the Department to represent the various Services concerned with the movement of agricultural commodities, livestock, etc., by air, attended the meeting.

Destructive Insect and Pest Act Advisory Board

This Board was constituted by Order in Council P.C. 840, April 21, 1922, and re-constituted by Orders in Council P.C. 7095, September 15, 1944, and P.C. 2057, April 26, 1949. The Chief of the Division of Plant Protection acts as Secretary.

The duties of the Board are to consider and recommend such amendments to the Destructive Insect and Pest Act and Regulations thereunder as it may deem necessary in the public interest, and advise the Division of Plant Protection, as required, in the formulation of policies with respect to the administration thereof.

One meeting was held during the year to consider the modification of previous policy to allow the importation of certain living insects required for entomological research.

Co-operation With Other Organizations

During the year, the Division of Plant Protection received co-operation and collaboration from the following:

The Divisions of Entomology, Botany and Plant Pathology, Fruit and Vegetable, Horticulture, and Health of Animals, Canada Department of Agriculture; the Department of National Revenue (Customs Division); the Department of National Health and Welfare (Food and Drug Divisions); the Department of Mines and Resources (Division of Metallurgy); the Quebec Department of Lands and Forests; the Provincial Departments of Agriculture in the various provinces, and the United States Bureau of Entomology and Plant Quarantine.

Announcement

DIVISION OF FOREST BIOLOGY

Early in 1951 Science Service announced the formation of the new Division of Forest Biology from the Unit of Forest Insect Investigations of the Division of Entomology and the Unit of Forest Pathology of the Division of Botany and Plant Pathology.

For the last several years a rapid expansion of staff and facilities has been necessary in the fields of forest entomology and forest pathology to cope with the many insects and diseases causing deterioration of our forests. As the many research programs were developed, it became apparent that many of the studies in entomology and pathology were facets of the same general problem and were often being undertaken in similar geographic areas. It became evident that a closer co-ordination of the two groups would result in a more satisfactory utilization of staff and would result also in economies in accommodations and equipment. A closer working relationship between the scientists interested primarily in forestry problems would result as well in a more comprehensive approach to the over-all forest research needs. It would provide also an administrative unit which could deal directly with the commercial forest interests, other federal research groups interested in forest conservation problems, and the provincial forestry departments.

The new Division will be organized under Mr. J. J. de Gryse as Divisional Chief and with two Units known respectively as the Unit of Forest Zoology and the Unit of Forest Pathology. Common fields of research will be co-ordinated at the divisional level and programs of research at various laboratories will be closely integrated.

DIRECTORY OF SCIENCE SERVICE OFFICES AND LABORATORIES

Director, Science Service—Science Service Bldg., Ottawa

Newfoundland

Plant Inspection Office	123 Water Street, St. John's
Entomological Laboratory (Field Crop Insects)	123 Water Street, St. John's

Nova Scotia

Entomological Laboratory (Fruit and Vegetable Insects)	Annapolis Royal
Plant Inspection	Dominion Public Bldg., Halifax
Laboratory of Plant Pathology (Fruit and Vegetable Diseases)	Kentville
Agricultural Chemistry Laboratory	Kentville
Seed Potato Certification	Experimental Station, Kentville

Prince Edward Island

Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Charlottetown
Entomological Laboratory (Field Crop and Vegetable Insects)	Charlottetown
Seed Potato Certification	Charlottetown

New Brunswick

Plant Inspection	Customs Bldg., Saint John
Animal Pathology Laboratory	Sackville
Laboratory of Plant Pathology (Potato Viruses; Field Crop, Fruit, and Vegetable Diseases)	Fredericton
Laboratory of Forest Pathology	Fredericton
Entomological Laboratory (Forest, Field Crop, Vegetable and Fruit Insects)	Fredericton
Seed Potato Certification	Customs Bldg., Fredericton

Quebec

Entomological Laboratory (Fruit Insects)	Hemmingford
Division of Animal Pathology (Administration, Animal Pathology, Poultry Pathology, Biological Products, Parasitology, and Laboratory Services)	Hull
Animal Pathology Laboratory	Macdonald College P.O.
Plant Inspection	105 McGill St., Montreal
Fumigation Station	785 Mill St., Montreal
Plant Inspection	3 Buade St., Quebec
Entomological Laboratory (Biological Control)	Quebec
Laboratory of Plant Pathology (Fruit and Vegetable Diseases)	St. Jean
Entomological Laboratory (Fruit and Vegetable Insects)	St. Jean
Laboratory of Plant Pathology (Fruit, Field Crop, and Vegetable Diseases)	Ste. Anne de la Pocatiere
Seed Potato Certification	P.O. Building, Ste. Anne de la Pocatiere
Entomological Laboratory (Vegetable Insects)	Ste. Anne de la Pocatiere

Ontario

Seed Potato Certification	Barrie
Parasite Laboratory (Propagation and Liberation of Parasites of Destructive Insects)	Belleville
Entomological Laboratory (Field Crop and Vegetable Insects)	Chatham
Seed Potato Certification	Ontario Agricultural College, Guelph
Laboratory of Plant Pathology (Special Crop and Vegetable Diseases)	Harrow
Entomological Laboratory	Harrow
Biological Control Laboratory	Queen's University, Kingston
Plant Inspection and Seed Potato Certification	Dominion Public Bldg., London
Plant Inspection	Federal Bldg., Niagara Falls
Poultry Pathology Laboratory	Poultry Bldg., Central Experimental Farm, Ottawa
Division of Bacteriology and Dairy Research (Administration, Dairy Research, Food Microbiology, Soil Microbiology, and General and Analytical Bacteriology)	Science Service Bldg., Ottawa
Division of Botany and Plant Pathology (Administration, Agricultural Botany, Systematic Botany, Arboretum, Herbarium, Mycology, Forest Pathology, Fruit and Vegetable Diseases, Seed-borne Diseases, and Plant Physiology)	Botanical Bldg., Central Experimental Farm, Ottawa
Division of Chemistry (Administration, Food Investigations, Plant Chemistry, Soil Chemistry)	Main Chemistry Bldg., Central Experimental Farm, Ottawa
Animal Chemistry Laboratory	Science Service Bldg., Ottawa
Division of Entomology (Administration, Field Crop Insects, Forest Insects, Systematic Entomology and National Insect Collection, Stored Product Insects, Biological Control, Fruit Insects, and Household and Medical Entomology)	Science Service Bldg., Ottawa
Plant Protection Division (Administration, Plant Inspection, and Seed Potato Certification)	Science Service Bldg., Ottawa
Laboratory of Plant Pathology (Fruit, Field Crop, and Vegetable Diseases)	St. Catharines
Entomological Laboratory (Forest Insects)	Sault Ste. Marie
Entomological Laboratory (Fruit Insects)	Simcoe
Plant Inspection	21 Lombard St., Toronto
Laboratory of Forest Pathology	144 Front St., Toronto
Entomological Laboratory (Fruit Insects)	Vineland Station
Plant Inspection	Canada Bldg., Windsor

Manitoba

Entomological Laboratory (Field Crop, Fruit and Vegetable Insects)	Brandon
Laboratory of Plant Pathology (Field Crop, Vegetable, and Seed-borne Diseases)	Winnipeg
Entomological Laboratory (Forest Insects)	Winnipeg
Entomological Laboratory (Stored Product Insects)	Dominion Public Bldg., Winnipeg
Plant Inspection and Seed Potato Certification	Dominion Public Bldg., Winnipeg

Saskatchewan

Plant Inspection and Seed Potato Certification	P.O. Bldg., Estevan
Entomological Laboratory (Forest and Shade Tree Insects)	Indian Head
Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Saskatoon
Laboratory of Forest Pathology	Saskatoon
Entomological Laboratory (Field Crop and Vegetable Insects)	Saskatoon

Alberta

Entomological Laboratory (Forest Insects)	Calgary
Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Edmonton
Seed Potato Certification	207 Northern Bldg., Edmonton
Veterinary Research Station	Lethbridge
Science Service Laboratory	Lethbridge
Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Lethbridge
Plant Inspection	Lethbridge
Entomological Laboratory (Field Crop, Vegetable and Livestock Insects)	Lethbridge
Plant Inspection	Post Office Bldg., Lethbridge

British Columbia

Entomological Laboratory (Field Crop, Fruit and Vegetable Insects)	Agassiz
Entomological Laboratory (Live Stock Insects)	Kamloops
Entomological Laboratory (Field Crop and Vegetable Insects)	Kamloops
Laboratory of Plant Pathology (Fruit, Ornamental Plant Vegetable and Seed-borne Diseases)	Saanichton
Agricultural Chemistry Laboratory	Saanichton
Laboratory of Plant Pathology (Fruit and Vegetable Diseases)	Summerland
Agricultural Chemistry Laboratory	Summerland
Entomological Laboratory (Fruit Insects)	Summerland
Animal Pathology Laboratory	University of British Columbia, Vancouver
Laboratory of Plant Pathology (Vegetable and Fruit Diseases)	University of British Columbia, Vancouver
Entomological Laboratory (Biological Control)	University of British Columbia, Vancouver
Plant Inspection and Seed Potato Certification	Federal Bldg., Vancouver
Entomological Laboratory (Forest Insects)	Vernon
Dominion Laboratory of Forest Pathology	Belmont Bldg., Victoria
Entomological Laboratory (Field Crop, Fruit and Vegetable Insects)	Parliament Bldg., Victoria
Entomological Laboratory (Forest Insects)	Central Bldg., Victoria
Plant Inspection and Seed Potato Certification	Parliament Bldg., Victoria

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